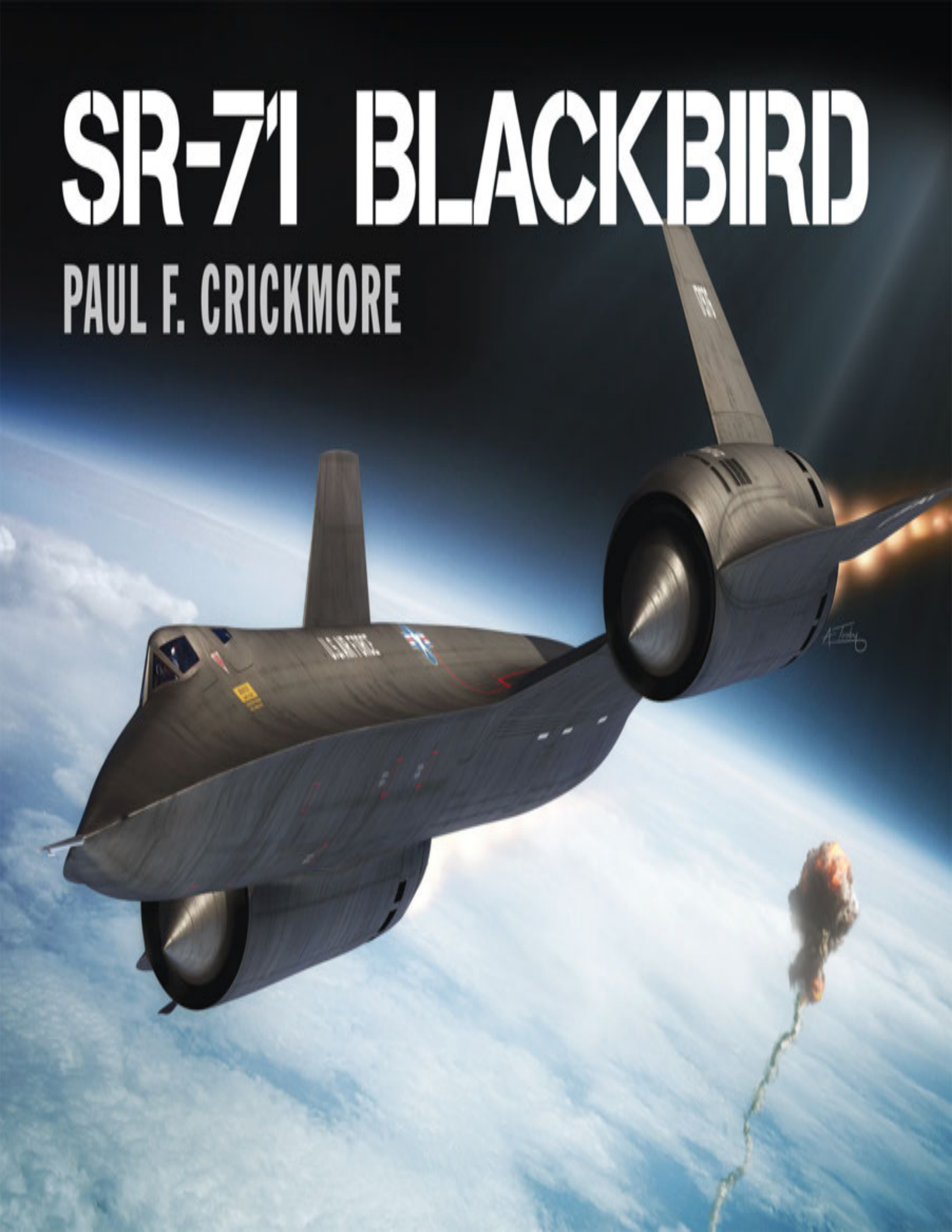
SR-71 BLACKBIRD

PAUL F. CRICKMORE



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OSPREY
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Dedication: To our wonderful grandsons Reuben Lewis and Isaac William

Wearing a David Clark S-1030 pressure suit, SR-71 pilot Major Tom Danielson is seen inside the Physiological Support Division van that will transport him and his RSO out to their waiting aircraft. (Paul F. Crickmore)

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LIST OF ABBREVIATIONS

AB: Air Base

ADC: Aerospace Defense Command

AFB: Air Force Base

AFLC: Air Force Logistics Command

AICS: Air Inlet Control System

ANS: Astro-inertial Navigation System

ARCP: Air Refueling Control Point

ASARS: Advanced Synthetic Aperture Radar System

BoB: Bureau of Budget

CIA: Central Intelligence Agency

CIT: Compressor Inlet Temperature

Comint: Communications Intelligence

DCI: Director of Central Intelligence

DEF: Defense Electronic System

DMZ: Demilitarized Zone

EAR: End Air Refueling

ECM: Electronic Counter Measures

EGT: Exhaust Gas Temperature

Elint: Electronic Intelligence

FCF: Functional Check Flight

FCS: Fire Control System

FISH: First Invisible Super Hustler

HRR: High Resolution Radar

INS: Inertial Navigation System

IPIR: Initial Photographic Intelligence Report

JCS: Joint Chiefs of Staff

KEAS: Knots Equivalent Airspeed

NACA: National Advisory Committee for Aeronautics

NASA: National Aeronautics and Space Administration

PAROP: Peacetime Aerial Reconnaissance Operations

Photint: Photographic Intelligence

PSD: Physiological Support Division

RADINT: Radar Intelligence

RAM: Radar Absorbent Material

RB: Reconnaissance Bomber

RCS: Radar Cross Section

RHAW: Radar Homing and Warning Receiver

RS: Reconnaissance Strike

RSO: Reconnaissance Systems Officer

SAC: Strategic Air Command

SAM: Surface to Air Missile

SEI: Scientific Engineering Institute

SRS: Strategic Reconnaissance Squadron

SRW: Strategic Reconnaissance Wing

SSM: Surface to Surface Missile

TEB: Tri-ethyl Borane

Despite A-12 pilots reporting a large number of Japanese photographers always taking pictures from “the other-side of the fence” every time they taxied out from the hangars at Kadena AB prior to a Blackshield mission, to date only a couple of poor-quality black and white frame grabs have emerged recording the deployment. (Lockheed Martin)

INTRODUCTION

A combination of extreme speed and altitude, together with the use of materials designed to reduce its RCS, combined to ensure that not a single “Blackbird” was shot down in over 20 years of flying over some of the most heavily defended areas of the globe. (Lockheed Martin)

During the Second World War the deep distrust that existed between the Soviet Union and the Western allies was put aside in order to confront

and defeat the common evil of Nazism. But scarcely had the last rifle barrel cooled from that war before relations between the two diametrically opposing political systems once again deteriorated. With much of Eastern Europe having been "liberated" and now under direct Soviet control from Moscow, an "iron curtain" descended and relations chilled into what has become known as The Cold War.

The wholesale upheaval and relocation of Soviet military bases and industrial complexes during the attempted Nazi invasion meant that the US and its allies had very little accurate information about their new adversary. So, given the size of the USSR, the closed nature of its society, and the level of technology prevailing at the time, one of the few options left to gather such vital information was to use reconnaissance aircraft. Initially these were converted bombers, as they had the necessary range for such missions, and so began PAROP (Peacetime Aerial Reconnaissance Operations).

Stand-off aerial reconnaissance in international airspace of peripheral targets provided a much needed partial solution to the West's intelligence gap. But overflight was the only real answer and that was contrary to international law. Such flights would therefore have to be covert; given their political sensitivity, they'd need to be sanctioned at the top of the command structure – the US President or, in the case of the United Kingdom, the Prime Minister.

To enable these slow, lumbering aircraft to fly higher and hopefully remain beyond the reach of Soviet interceptors the crew's heavy armor protection was removed. Nonetheless, it's perhaps not surprising that it wasn't long before the first of several such reconnaissance flights fell victim to Soviet interceptors. The first occurred on April 11, 1950, when a US Navy

Consolidated PB4Y Privateer, nicknamed “Turbulent Turtle,” was shot down and crashed into the Baltic Sea, off the coast of Soviet-occupied Latvia. There were no survivors from the crew of ten.

Eighteen months later, on November 6, 1951, another US Navy aircraft was shot down by Soviet fighters while on a reconnaissance mission. This time it was a P2V-3W Neptune and yet again all ten on-board were killed in the attack. On June 13, 1952, the first USAF aircraft fell to Soviet guns, when an RB-29 assigned to the 91st Strategic Reconnaissance Squadron (SRS) was shot down by two Soviet MiG-15s, killing all 12 crew members. Then, just four months later, a mind-numbing near-repeat performance was endured by the same squadron on October 7, 1952, when all eight of the crew in another RB-29 were shot down by Soviet La-11 fighters while conducting a recce mission northeast of the island of Hokkaido, Japan. As the losses continued to mount it became apparent that a different approach to prosecuting this vital mission had to be found.

In early 1954, a radical answer to the problem was being sought independently by both the USAF and Lockheed. The Air Force had placed outline developmental contracts with Bell and Fairchild for a custom-built, single-seat, jet-propelled, extremely high-altitude reconnaissance aircraft. Meanwhile, Clarence L. “Kelly” Johnson (the legendary boss of Lockheed’s famous Skunk Works secret manufacturing plant) had developed a design designated the CL-282. In the event Johnson’s modified design, designated U-2, went into production, and, perhaps as radical as the design of the new aircraft, it would be flown initially not by Air Force, but by Central Intelligence Agency (CIA) pilots!

CHRONOLOGY

1956

August 16 Project Rainbow begins in an attempt to render the U-2 “invisible to Soviet radar.”

1958

January Classified cryptonym “Gusto” assigned to Phase 2 of Project Rainbow as design work begins to find a U-2 replacement.

Spring CIA invites Convair to participate in Project Gusto.

1959

August 29 Lockheed’s A-12 design declared winner of Project Gusto competition and an advanced feasibility contract is awarded for what becomes Project Oxcart.

1960

March 16/17 Kelly Johnson discusses the possibility of building an interceptor version of the A-12 for the US Air Force with the Air Force Secretary for Research and Development.

May 1 U-2 flown by CIA pilot Francis Gary Powers shot down and captured during a clandestine overflight by a Soviet SA-2 Guideline, Surface to Air Missile (SAM).

October Lockheed receives letter to proceed with development of YF-12A interceptor in a program codenamed Kedlock.

1961

January Kelly Johnson proposes RB-12 (RB for Reconnaissance Bomber) to USAF – this evolved into the RS-12 (RS for Reconnaissance Strike) but was a “paper only” aircraft, i.e. a prototype was never built.

1962

April 30 Lockheed chief test pilot Lou Schalk successfully completes the A-12’s first official flight – due to early development problems, the aircraft was powered by two Pratt & Whitney J75 engines.

October 10 Skunk Works receives authorization to begin studies into building an unpiloted, Mach 3+ drone, which evolved into the D-21.

October 27 USAF pilot Major Anderson shot down and killed by another SA-2 SAM while flying a U-2 over Cuba during the missile crisis.

December 6 Kelly Johnson begins work on his R-12 “Universal” aircraft. It was this design that was later designated SR-71.

1963

January 15 First flight of an A-12 powered by two Pratt & Whitney J58 engines completed.

February 18 Lockheed awarded pre-contractual authority to build six R-12s (SR-71s) on the understanding that orders for an additional 25 would follow before July 1.

May 24 First A-12 is lost during a test sortie – Ken Collins, the CIA pilot, safely ejects.

August 7 Jim Eastham successfully completes the first flight of a YF-12 from Area 51.

1964

February 29 President Lyndon B. Johnson announces the existence of the “A-11” (A-12) program.

July 25 President Lyndon B. Johnson makes a second announcement confirming the existence of the SR-71 program.

December 22 First flight of D-21/M-21 combination flight from Area 51 by Bill Park.

December 22 First flight of SR-71 prototype from Palmdale by Bob Gilliland.

1965

March 18 YF-12A first AIM-47 missile.

May 1 YF-12A used to set nine world speed and altitude records.

June 1 SR-71/YF-12 Test Force formed at Edwards Air Force Base (AFB).

1966

January 6 SR-71B pilot trainer delivered to 4200th Strategic Reconnaissance Wing (SRW), at Beale AFB.

January 25 First SR-71 is lost during Lockheed test sortie; pilot Bill Weaver survives, but flight test engineer Jim Zwayer is killed.

May 10 First SR-71A delivered to 4200th SRW, at Beale AFB.

June 25 4200th SRW redesignated 9th SRW.

July 30 D-21/M-21 Tagboard program canceled.

1967

May 22 First of three A-12s deployed from Area 51 to Kadena AB, Okinawa, as part of Operation Blackshield to monitor North Vietnam.

May 31 Mele Vojvodich successfully completes the first ever operational mission of an A-12 in aircraft 60-6937 (Article 131).

1968

January 5 Lockheed receives notification from US Air Force to cancel the YF-12A Kedlock program.

January 26 First overflight of North Korea in A-12 made by Jack Weeks in aircraft 60-6937 (Article 131).

March 8 First of three SR-71As deployed on detachment to Kadena AB, Okinawa, ready for their first operational missions.

March 21 Majors Jerry O'Malley and his Reconnaissance Systems Officer (RSO) Ed Payne successfully complete the first ever SR-71 operational mission in aircraft 61-7976.

May 25 Following 20 months of prevarication, a decision to terminate the A-12 Oxcart program in favor of the SR-71 Senior Crown program is finally endorsed by President Johnson and implemented.

July 26 First confirmed firing of two North Vietnamese SA-2s against an SR-71.

November 1 9th SRW receives the Air Force Outstanding Unit Award.

1973

October 12/13 The first of nine SR-71 non-stop missions from the US east coast to the Middle East and back is successfully completed during the Yom Kippur War.

1974

September 1 & 13 Current world speed records New York–London, and London–Los Angeles established by crews flying SR-71A serial 61-7972.

1976

July 27/28 SR-71A serial 61-7958 establishes a series of world speed and altitude records.

September 6 Majors Rich Graham and Don Emmons complete the first SR-71A operational mission from the UK in aircraft 61-7962.

1981

August 26 North Korea fires an SA-2 in an attempted shoot-down of SR-71A 61-7976.

1986

April 13 The first of three SR-71A flights is successfully completed from the UK over Libya following Operation El Dorado Canyon.

1987

July 22 First operational SR-71 flight from Kadena into the Gulf completed.

1989

November 22 All USAF SR-71 operations terminated.

1990

January 26 SR-71 decommissioned in ceremony at Beale AFB.

March 6 SR-71A 61-7972, flown by Lt Cols Ed Yeilding and J. T. Vida, establishes current world speed record between the west and east coast of the USA during positioning flight to Dulles Airport prior to the aircraft being displayed at the Smithsonian Museum.

1995

January 5 Limited reactivation plan for three SR-71s begin.

1997

October 10 Final USAF SR-71 flight flown in 61-7967.

October 14 President Clinton line-item vetoes the limited SR-71 program with immediate effect.

1999

October 9 NASA crew Rogers Smith and Bob Meyer fly SR-71A 61-7980 on the type's final ever flight at the Edwards AFB Open Day.

A-12 DESIGN AND MANUFACTURE

Three SR-71s are seen being built inside the Skunk Works in Burbank, California. Note how the fuselage forebody is joined to the wing section, optimizing design flexibility, and also the black components constructed from RAM to reduce the aircraft's RCS. (Lockheed Martin)

On July 4, 1956, after a demanding flight lasting 8 hours and 45 minutes the frail-looking U-2 returned to roost at Wiesbaden Air Base (AB),

West Germany. Masquerading as an aircraft belonging to the National Advisory Committee for Aeronautics, NACA (predecessor of the National Aeronautics and Space Administration – NASA), and supposedly participating in high-altitude weather studies, the aircraft actually belonged to the CIA, and the historic flight marked the beginning of Project Aquatone, a program of high-altitude, "covert" overflights of the Soviet Union.

Equipped with a state-of-the-art camera system, the mission, approved by US President Eisenhower, was tasked to gather photographic intelligence (Photint), and electronic intelligence (Elint) of the West's Cold War adversary. After the film "take" was flown back to the States and processed in downtown Washington DC, the results from this and five other follow-on flights was staggering. The detailed imagery (codenamed Chess), covered over 15,000 square miles, and the intelligence reports that it generated (codenamed Talent), enabled the CIA, for the first time, to confidently and accurately conclude that the West's long-held belief that the Soviets possessed a numerically superior bomber fleet (the so-called "bomber gap"), was a fallacy. Talent also provided the US intelligence community with a vast amount of other details about the Soviet Union's nuclear, military, and industrial capabilities.

A US National Intelligence Estimate, issued while the U-2 was being developed, noted that "although the Soviets have made great strides in radar development," their standard S-band and V-beam early-warning radar (NATO codename Token), had no capability above 60,000 feet. So with this in mind, the CIA had assured Eisenhower that the chances of the Soviets detecting, let alone tracking, its U-2s flying at 70,000ft were extremely slim. They were wrong. Even during that July 4 overflight, the pilot Hervey Stockman reported in his debriefing that on peering through the aircraft's

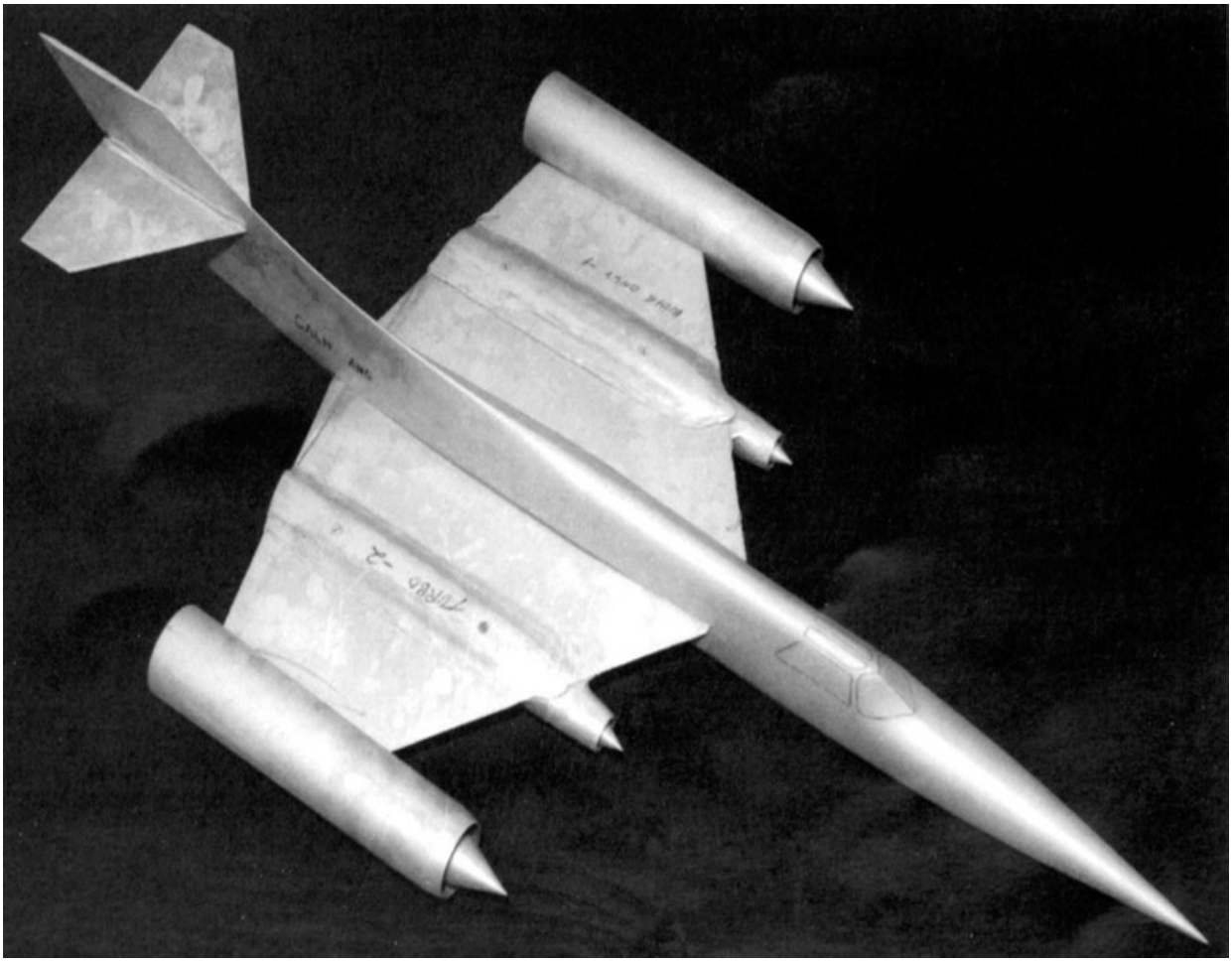
drift-sight he saw several MiG fighters climbing in an attempted intercept. It's therefore not surprising that on July 10, the Soviets' first protest about the flights was communicated to Eisenhower, and he temporarily suspended further overflights, despite their importance to national security – the violation of a sovereign state's airspace is, after all, contrary to international law. In addition the President issued a challenge to the CIA: "Make the U-2 invisible to radar." In response, on August 16, 1956, Director of Central Intelligence (DCI) Allen Dulles, and Special Assistant for Planning and Coordination, Richard Bissell, convened a meeting with Kelly Johnson, together with a number of prominent US scientists. Their task: to develop "electronic camouflage" for the U-2 to render it invisible to Soviet radars – Project Rainbow had begun.

By the following year Phase 1 of Rainbow was being implemented at Area 51 – the U-2 test site. Radar Absorbent Material (RAM) was applied to the U-2's lower fuselage. In a further bid to reduce the U-2's Radar Cross Section (RCS), wires and ferrite beads were positioned around the aircraft's wing planform, fuselage, and vertical tail. In July 1957, and on the back of the Project Rainbow modifications, President Eisenhower reluctantly gave the CIA clearance to resume limited U-2 overflights of the Soviet Union. But these measures only met with limited success as it was still possible for Soviet radars to detect the flights. What was needed was a more radical approach, and in January 1958 the CIA assigned the classified cryptonym Project Gusto, to Phase 2 of Rainbow. This was to be the development of a U-2 replacement aircraft.

Lockheed Skunk Works boss Clarence L. “Kelly” Johnson was the legendary designer behind the F-104 Starfighter, U-2, A-12, YF-12, and SR-71. (Lockheed Martin)

One of Kelly Johnson’s early proposals for Gusto was a “stealthy” but subsonic design, designated Gusto Model 2A. In parallel with Projects Aquatone, Rainbow, and Gusto, the Skunk Works also worked on a reconnaissance project for the USAF, named Suntan. Designated the CL-400 (the initials coming from Kelly, that is Clarence L.), this non-stealthy reconnaissance aircraft was to be capable of cruising at Mach 2.5 and altitudes in excess of 90,000ft and its engines were to be fueled by liquid hydrogen. By February 1958, however, Johnson was concerned with the lack of “stretch” in the design and the difficulty in pre-positioning highly volatile liquid hydrogen at various forward operating locations around the globe. He

therefore convinced the Air Force to cancel the project. Lockheed returned $90 million to the Air Force, but the project convinced Johnson that his future high-speed designs should be fueled by more conventional hydrocarbon fuels.



Archangel II powered by two J58s and two wingtip-mounted ramjets was one of several design iterations Kelly Johnson and his team evaluated during Phase 2 of Project Rainbow. (Lockheed Martin)

In June 1958, a team working for the Scientific Engineering Institute (SEI), a CIA proprietary organization based in Boston, completed a report for Bissell that became known as the Blip Scan Study. It demonstrated that an aircraft like the U-2 would take 10 minutes to fly through a surveillance radar's

detection zone – but, flying some 20,000ft higher, at 90,000ft and at Mach 3, it would clear this zone in just 4 minutes. This would make such an aircraft exceptionally difficult to track, thereby significantly reducing its chances of both detection and interception. The report led Bissell to set specific targets for Gusto, namely that the U-2 replacement should have a cruise speed and altitude of Mach 3 and 90,000ft respectively, and that its RCS should be no more than 10 square meters, and preferably less than 5.

In April 1958 Johnson began sketching his first Mach 3 Concept Formulation Study in what would become known as his Archangel notebook (within the Skunk Works, the high-flying U-2 was often referred to as "Kelly's Angel," but as its replacement would fly even higher, it was referred to as the "Archangel"). Between then and July 1959, he and his Skunk Works team worked through many different design iterations, designated Archangel 1, or A-1, through to A-12.

In spring 1958 Bissell invited Robert Widmer, head of advanced development at Convair and designer of the supersonic B-58 Hustler bomber, to participate in Project Gusto. His motivation for so doing was based upon due diligence considerations and to assuage any criticism when the time came to award a multi-million dollar contract. Others have said that it was also to keep Johnson, who could be extremely headstrong, focused on all aspects of the design – including the aircraft's RCS.

To help evaluate the various design proposals submitted by Convair and Lockheed, Bissell set up a team of independent experts under the chair of Dr. Edwin Land of the Polaroid Corporation. Over the period of Gusto, the so-called Land Panel met – usually in Land's Cambridge, Massachusetts office – on six occasions, Widmer and Johnson presenting their proposals independently of one another.

As a basis for its Gusto design submission Convair worked on a variation of a proposed two-stage parasite bomber designated Super Hustler. Named FISH (First Invisible Super Hustler), the extremely stealthy Mach 4, ramjet powered proposal would need to be launched at supersonic speed from a B-58B.

In November 1958, Johnson and Widmer presented A-3 and FISH respectively to the Land Panel who were particularly impressed by the Convair submission – and in December the company was given the go-ahead to proceed with detailed design development. The critical issue for Johnson was FISH's much lower RCS; nonetheless, Land told him to keep alternative proposals available in case the Convair design was unable to meet "desired technical features".

During the following months Johnson worked on several more design variations, A-4, A-5 had some stealth characteristics, but A-6 made no concessions to reduced RCS. The dichotomy Kelly grappled with is what appeared to be a mutually exclusive relationship between performance and low RCS; so often a design that met one requirement failed to meet the other and vice versa. Moreover, he argued that the speed of Soviet radar development and their inevitable use of more diverse frequencies would further complicate and increase the time and effort required to resolve these conflicting paradigms.

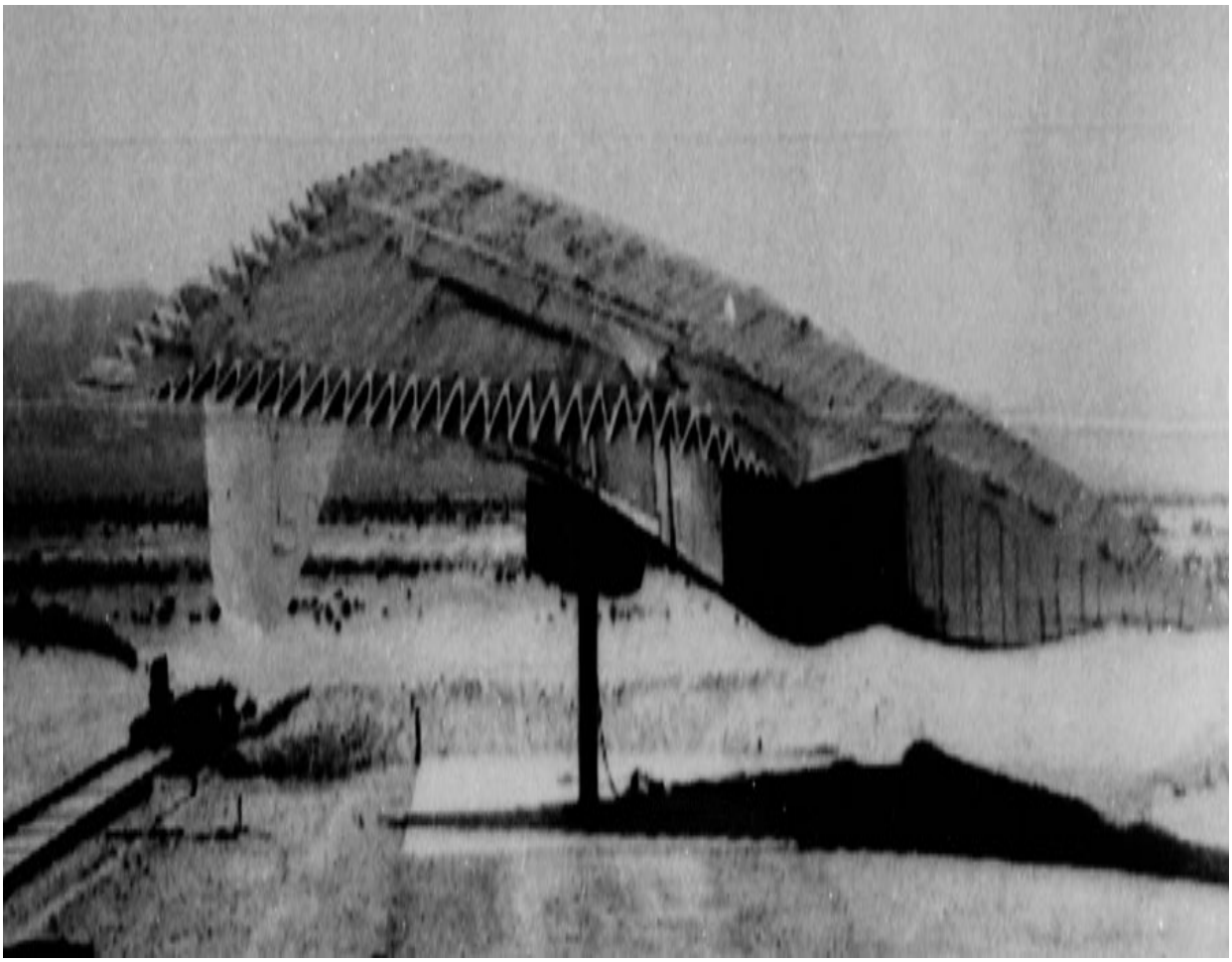
Three permutations of the A-7 design, together with designs A-8 and A-9, were judged by the Skunk Works to be unworkable – their mission radius was too small. A-10 met the laid down performance objectives; however, its proposed General Electric J93 engine was 18 months behind the development of Pratt & Whitney's J58. Therefore, a new design designated A-11 and utilizing the J58 was formulated, but yet again, few concessions were made to reducing the design's RCS.

By the end of May 1959, the SEI team at Cambridge had completed a comparison evaluation between the A-11 and FISH and forwarded their report to the Land Panel for their June meeting. Kelly Johnson was convinced that Lockheed was now out of the competition, but all was not lost. That same month Strategic Air Command (SAC) failed to order the B-58B, and without the stretched bomber with its uprated engines, the parasite FISH platform couldn't be launched.

Convair was now on the back foot and had just a month to completely redesign its entry for the competition, which needed to be able to take off without the need for a launch aircraft. Convair's standalone proposals developed through a series of design variations designated Smelt, Herring,

and finally Kingfish – which is perhaps as well as it's difficult to imagine any pilot wanting to brag about flying an aircraft named Smelt!

Powered by two J58 turbojets, Kingfish was designed to cruise at Mach 3.2, reach 94,000ft at the end of its cruise-climb, and have an un-refueled range of 4,000 nautical miles. To reduce its RCS the intakes were shielded from below by the wing leading edge, and the entire wing planform was serrated – the void being filled with wedge-shaped dielectric inserts; these turned incident radar waves into heat, dissipating energy as it traveled toward the tip of the wedge, thereby reducing RCS significantly. The technique is known as edge softening.



Developed from FISH, here Convair's Kingfish is seen inverted while undergoing RCS testing. (Lockheed Martin)

Lockheed was instructed by the Land Panel to redesign its A-11 submission and incorporate RCS reduction techniques – even to the detriment of cruise altitude. This became Kelly Johnson's A-12 design. Final proposals from both companies were submitted on August 20, 1959, and nine days later Lockheed received official notification that they'd won Gusto with their A-12 design. They were awarded $4.5 million for a six-month feasibility contract, during which time they were expected to verify their RCS findings using a full-scale model which was tested at the Area 51 Radar Target Scatter (RAT SCAT) range. Gusto was now terminated and a new classified cryptonym was allotted to the program, Oxcart. On February 11, 1960, a contract was signed between the CIA and Lockheed worth $96.6 million (just short of $1 billion in today's money), for the manufacturing and testing of 12 A-12s – including one two-seat pilot trainer.

MANUFACTURE

Looking today at the SR-71's complex shape it's difficult to imagine that it was designed by engineers primarily using slide rules, as computers were in their infancy! The aircraft was very much a leap into the technical unknown – to put this into context, the best USAF front-line fighters of the day were the early century series jets, such as the F-100 Super Sabre and F-101 Voodoo. In a single bound, the A-12 would operate at sustained speeds and altitudes treble and double respectively of these contemporary fighters. Johnson would later remark that virtually everything on the aircraft had to be invented from scratch.

Operating above 85,000ft (16 miles high), the ambient air temperature was often below minus 60 degrees Celsius and the atmospheric air pressure just 0.4 pounds per square inch. But cruising in afterburner at Mach 3.2 (that's 2,200mph or a mile every 2 seconds, which is faster than the muzzle velocity of a 0.30 caliber bullet fired from a hunting rifle), airframe temperatures

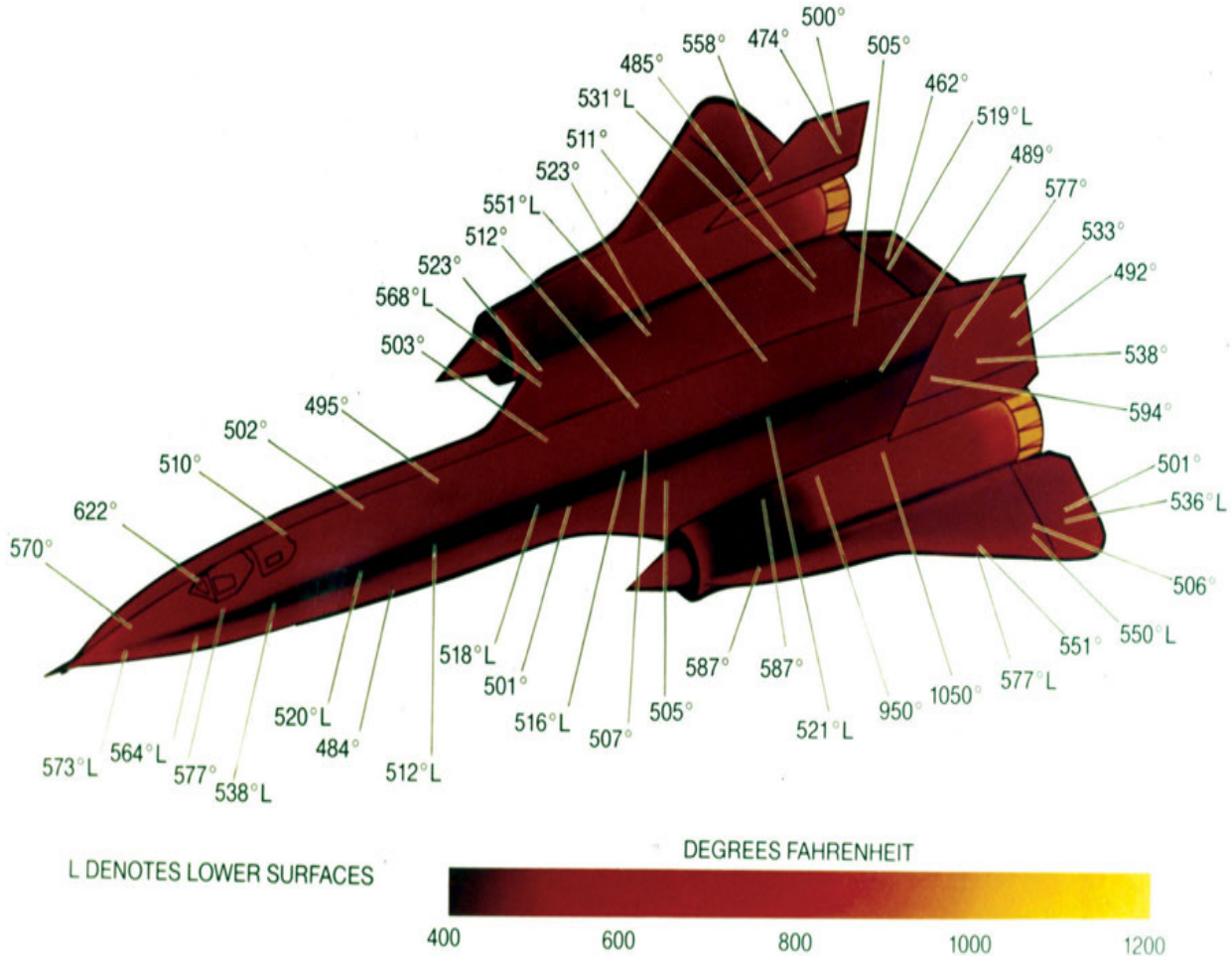
soared due to frictional heating, from between 245 and 565 degrees Celsius. Thermodynamic considerations ruled out the use of aluminum because it would become too soft in such a “thermal thicket.” High-strength composites weren’t available in the early 1960s; therefore, it was decided to use titanium, which accounts for 85 percent of the aircraft’s structural weight. The remaining 15 percent comprises composite materials which were used in the production of RAM. The advantage of using titanium over stainless steel is that it too can withstand high operating temperatures, but weighs half as much while having the same tensile strength.

The next problem was from where to source this precious alloy. The Skunk Works supplier, Titanium Metals Corporation, had only limited reserves, so the CIA conducted a worldwide search and, after setting up dummy companies, managed to surreptitiously purchase the titanium sponge from one of the world’s leading exporters – the Soviet Union! The subterfuge and circuitous supply routes were so successful that the Soviets never discovered that they were inadvertently supplying the material essential for constructing an aircraft that was being built specifically to spy on them!

The particular titanium selected was B-120/Ti-13V-11Cr-3A1, which can be age hardened to tensile strengths up to 200 kilopounds per square inch. Using this advanced material certainly wasn’t without problems – titanium is not compatible with chlorine, fluorine or cadmium. So, for example, a line drawn on sheet titanium with a Pentel pen will eat a hole through it in about 12 hours; as a result, all Pentel pens were recalled from the shop-floor. Early spot-welded panels produced during the summer had a habit of failing, while those built in the winter lasted indefinitely. Diligent detective work discovered that to prevent the formation of algae in the summer, the Burbank water supply was heavily chlorinated. Subsequently, the Skunk Works washed all titanium parts in distilled water. As thermodynamic tests got underway, bolt heads began dropping from installations. This, it was discovered, was caused by tiny cadmium deposits that remained after cadmium-plated spanners had been used to apply torque. As the bolts were heated in excess of 320 degrees Celsius, their heads simply dropped off. The remedy: all cadmium-plated tools were removed from tool boxes.

One test undertaken studied thermal effects on large sheets of titanium wing panels. When heated to the computed heat flux expected in flight, it warped

into a totally unacceptable shape. This problem was solved by manufacturing chord-wise corrugations into the wings' outer skins. At the design heat rate, the corrugations merely deepened a few thousandths of an inch and on cooling returned to their original shape. Kelly recalled he was accused of "trying to make a 1932 Ford Tri-motor aircraft go Mach 3," but added that "the concept worked fine."



The awesome temperatures encountered by the Blackbirds while cruising in afterburner at 2,200mph meant that aluminum would become too soft; therefore titanium was used to build most of the aircraft. (Lockheed Martin)

The reason behind the aircraft's "menacing" black paint scheme is grounded in Kirchoff's law of thermal radiation. This basically states that a good

absorber is a good emitter, and a good absorber of heat is a black body. Since convective heating decreases with increasing altitude and radiation is independent of altitude, in order to take advantage of this radiation component when cruising above 70,000ft, the aircraft required a high surface emissivity. Black paint generated an emissivity value of 0.93 compared with 0.38 for bare titanium, resulting in a reduction in surface temperature of 15–30 degrees Celsius, a gain thought well worth the 60lb in additional weight of paint!

LAYOUT AND STEALTH

In addition to reducing skin temperature, the black paint covering the aircraft was embedded with very small iron particles that were typically 3/10 microns (millionths of a meter), in diameter – about 1/10 the thickness of a human hair. This reduced the aircraft's RCS when exposed to high-frequency target acquisition radars, by partially absorbing and partially scattering incident radar waves. It also caused waves striking the surface at a grazing angle to travel along its surface experiencing continuous attenuation. To reduce edge returns, edge-softening techniques described earlier were also used around the leading and trailing edges of the wings.

Shape was a major factor that enabled the "Blackbirds" to attain not just their phenomenal speed and altitude capability but also an extremely low RCS. The exterior of the A-12, YF-12A, and SR-71 is characterized by a delta-wing, into which is blended the aft fuselage and two large engine nacelles, each mounted at mid-semi-span. Two "all-moving" vertical fins located on top of each nacelle were canted inboard 15 degrees from the vertical to reduce the aircraft's radar signature when viewed from the side. A large, aft-moving inlet spike, or center-body, protrudes forward from each engine nacelle, which helped to regulate mass airflow to the two Pratt & Whitney J58 engines. The inlet spikes also helped to shield the engine's compressor face from unwanted radar returns, and their conical walls were covered in RAM which again reduced RCS.

The fuselage is essentially a ring-stiffened cylinder of circular cross-section. The fuselage sides then flare out, creating sharply blended chines, the resultant cross-section resembling a two-dimensional flying saucer, which reduces radar returns from the side by acting as a surface wave-guide. The fore and aft fuselage sections were joined during construction at fuselage station 715, the wing and aft fuselage section being essentially the same for all three Blackbird variants – thereby providing a level of commonality and reduced manufacturing costs. The wedges of RAM located within the wings and mentioned earlier were also used within the A-12's forward fuselage forebody. This wasn't, however, the case with the YF-12A or SR-71. Both designs instead utilized sheets of RAM, which enabled weapons and equipment bays to be cut and located in the undersides of these aircraft – these didn't feature in the A-12. The primary reconnaissance-gathering system on the A-12 was a high-resolution panoramic camera, which was located in a large pressurized compartment behind the pilot and referred to as the Q Bay. Instead, this same space was converted and used to create a second crew member position in the M-21, YF-12A, and SR-71.

ENGINE

The specified power plant for the Blackbird variants was two Pratt & Whitney JT11D20A engines (designated J58 by the US military). Known as "JJ" engines when installed in the A-12 (note: the AT-12 two-seat pilot trainer was equipped with less powerful Pratt & Whitney J75 engines throughout its life, which enabled it to reach a maximum speed of Mach 2.0), each engine developed 32,500lb of thrust. However, since the SR-71 was heavier than the A-12, its modified "YJ" engines produced 34,000lb of thrust.

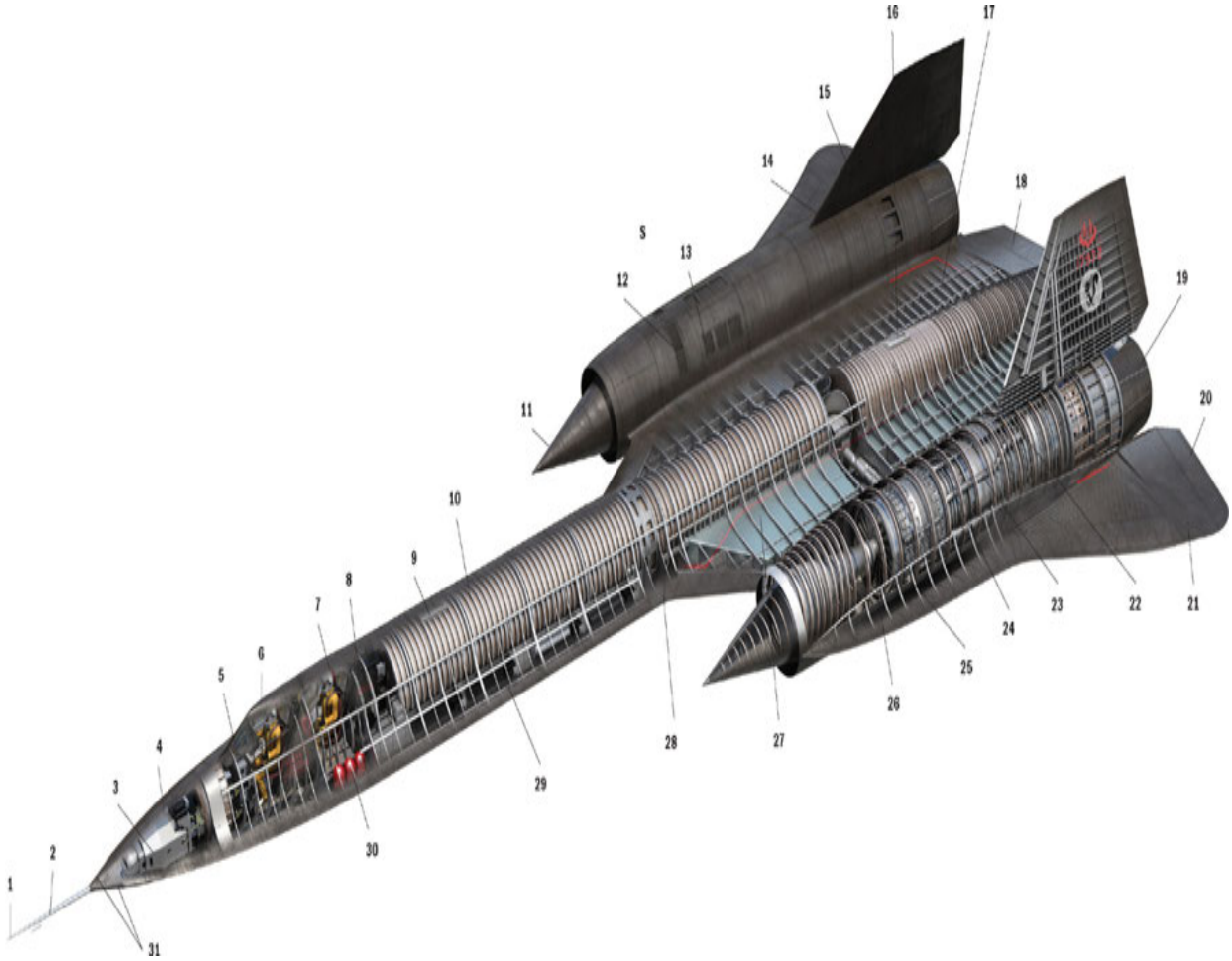
The origins of this high-bypass ratio afterburning engine can be traced back to an earlier, ill-fated US Navy program, the Martin P6M jet-powered flying boat. When this program was canceled, Pratt & Whitney had to undertake major redesign work to enable it to operate continuously at Mach 3.2.

To ensure efficient engine operation throughout the aircraft's vast envelope, Pratt & Whitney's Robert Abernathy developed a unique bleed-bypass system. It bled air from the fourth stage of the engine's nine-stage, single-spool axial-flow compressor, and channeled this excess air through six low bypass ducts. This air was then re-introduced into the turbine exhaust, just in front of the afterburner. This reduced the Exhaust Gas Temperature (EGT) and amazingly produced almost as much thrust as the main flow that had passed through the rest of the engine! The system cut in when the Compressor Inlet Temperature (CIT) reached between 85 and 115 degrees Celsius (approximately Mach 1.9).

FUEL SYSTEM

Due to thermodynamic heating at high-Mach cruise, normal JP-4 fuel was ruled out as it would have exploded in the "wet" (unlined) fuel tanks. Instead a unique fuel and fuel system was developed. The fuel was designated PF-1 for the A-12, and JP-7 for the SR-71. Developed by Pratt & Whitney, in partnership with Ashland, Shell and Monsanto, it remained stable despite the high-temperature environment and was used first as a hydraulic fluid to activate the main and afterburner fuel nozzles, before being injected into the fuel burners at over 350 degrees Celsius and 130 pounds per square inch. Such high fuel burn temperatures presented the design team with yet another problem: standard electrical plugs couldn't ignite the fuel. This was overcome by developing a unique chemical ignition system, involving the chemical tri-ethyl borane (TEB). Extremely flash sensitive when oxidized, a small tank of the substance was carried on board the aircraft and used to start or restart the engines and afterburners on the ground or in the air. To ensure that the system remained inert when not in operation, gaseous nitrogen was used to pressurize the TEB tank and power the piston that injected it into the burner cans. As fuel was burnt, gaseous nitrogen was also pumped into the fuel tanks. This simultaneously prevented fuel vapor ignition and pressurized the tanks, preventing them from being crushed as the aircraft descended to lower levels to either air refuel or land.

Development of a durable fuel tank sealant was an ongoing problem throughout the life of the SR-71. Constant high-Mach thermodynamic heating followed by rapid cooling during the air refueling process, when cold fuel was pumped into the tanks at 5,000lb per minute, invariably caused the silicon-based sealant to crack, causing fuel to leak from numerous gaps – hence the large puddles of fuel found on the hangar floor beneath the Blackbirds as they were being readied for flight.



This cutaway of SR-71 61-7972 (see Surviving Aircraft Histories) shows the main features of the aircraft:

1. Compensated pitot static probe

2. Offset hemispherical head flow-direction sensor

3. Optical Barrel Camera (OBC)

4. Detachable nose section

5. Heat dispersion fin

6. Retractable rear-facing periscope

7. RSO's rear cockpit canopy

8. ANS star tracker aperture

9. In-flight refueling receptacle

10. Forward fuselage fuel tankage

11. Right engine intake spike

12. Forward bypass doors

13. Aft bypass doors

14. Right fixed vertical fin root

15. All-moving starboard fin, canted inboard 15 degrees from the vertical

16. Brake parachute doors

17. Stand-off clips used to secure wing skin to structure

18. Starboard inboard elevon

19. Left engine ejector flaps

20. Left outboard elevon

21. Left outboard wing section with RAM fitted to reduce aircraft's RCS

22. Aft wing box section

23. One of six engine compressor bypass ducts

24. Aft fuselage fuel tankage

25. J58 engine compressor

26. Main undercarriage wheel-well

27. Forward wing box section, including wing fuel tankage

28. Fuselage joint 715 where front fuselage forebody is mated to the wing section

29. Left fuselage chine, within which are housed equipment bays

30. Liquid oxygen bottles

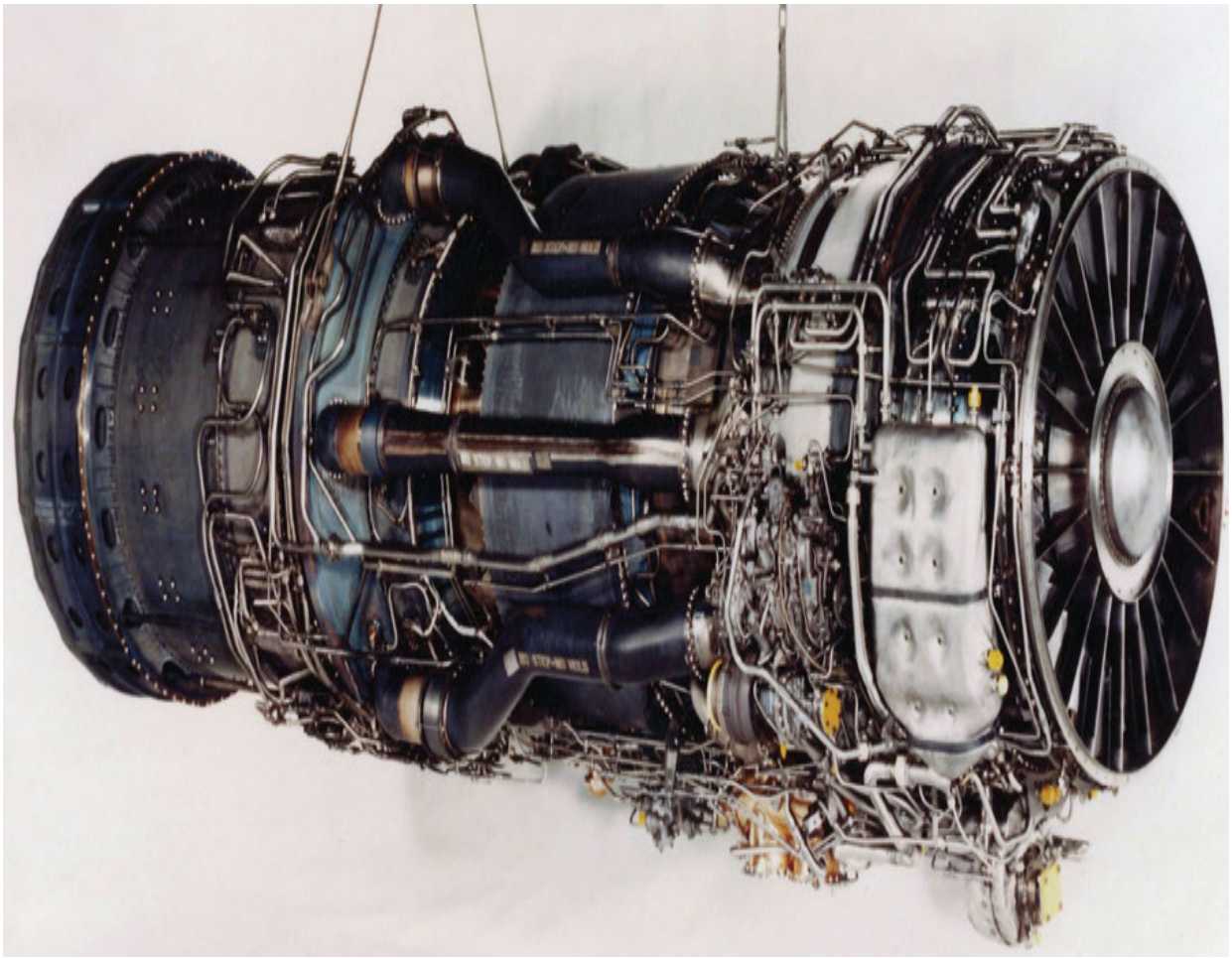
31. Left and right DEF A2 receive antennas

AIR INLET CONTROL SYSTEM (AICS)

The Blackbirds also boasted a unique air inlet and ejector nozzle system that together vastly supplemented the thrust generated by its engines when cruising at Mach 3.2. To do this the AICS regulated the massively varying airflow throughout the aircraft's entire flight envelope, ensuring that the J58s received air at both the correct velocity and pressure.

At low power settings additional airflow was provided through six forward bypass doors. Once airborne, these doors closed automatically as the undercarriage retracted. The inlet spike created a shockwave to form just outside the inlet throat; this slowed air entering the compressor face down to subsonic speeds – turbo jets can't work with supersonic air. At Mach 1.6, the inlet spike unlocked and began to slowly move rearward as the aircraft's speed continued to increase, achieving its fully aft position of 26in at Mach 3.2, the inlet's most efficient speed. These changes to the inlet's shape increased the amount of air available to the engine while compressing air that entered the inlet. A peripheral "shock trap" stabilized the shockwave and used tertiary air via a secondary bypass passage, which cooled the exterior of the engine and augmented thrust as it exhausted through the ejector nozzle. By carefully dove-tailing together these parameters, the inlet was able to generate inlet pressure of 18psi, when at 82,000ft the outside air pressure was around 0.4lb per square inch! This vast pressure differential between the two air masses generated a large pressure gradient, which in turn produced a forward thrust vector. So at Mach 3.2 over 50 percent of the total thrust was being produced by the inlet; a further 30 percent was produced by the tertiary air entering the ejector, leaving just 20 percent generated by the J58 engine! If, however, this delicate pressure-balancing trick was disturbed, it brings us to another Blackbird idiosyncrasy, the "unstart." Unstarts occurred when the shockwave was "belched" forward from the inlet, causing an instant drop in inlet pressure and an immediate loss of thrust. With each engine positioned at mid-semi span, the shockwave departure manifested itself in a vicious yaw in the direction of the

“unstarted” engine. Sometimes these were so strong that crew members would have their helmets knocked against the cockpit canopy framing. Recovery from such an incident required the pilot to re-sequence the inlet in order to get it “restarted.” This involved switching the inlet spike to the forward position and opening the forward bypass doors to recapture and reposition the shockwave. The spike and bypass doors were then returned to their correct positions. “Unstarts” were a regular feature of early A-12 flights. However, as computer software improved, a system known as the Digital Automatic Flight and Inlet Control System (DAFICS) was developed for the SR-71, which was able to achieve near-perfect inlet airflow control, which in turn practically rid the jet of its “unstart” problems.



The mighty Pratt & Whitney J58 developed 32,500lb of thrust in its so-called “JJ” configuration when installed in the A-12 and 34,000lb in its “JY” configuration when equipping the SR-71. (Pratt & Whitney)

INERTIAL NAVIGATION SYSTEM (INS)

Since GPS wasn't available in the 1960s and '70s A-12s used an INS. It was completely self-contained and provided the principal navigation references to the aircraft without recourse to any electromagnetic radiation or other external references. The system provided attitude, true heading, command course, ground speed, distance, and geographic position data for automatic or manual navigation between way-points on the flight plan. The pilot could update position information periodically to correct gyro drift by taking fixes with a view scope that provided an optical display of the terrain along the flight path.

The SR-71, however, featured an Astro Navigation System (ANS). This system provided position updating automatically to the INS by astrotracking, which was achieved via a pre-programmed tracker mechanism mounted on a gimballed platform that tracked, at any one time, six of the 52 most prominent visible stars by day or night.

CAMERAS

The camera "packages" available to the A-12 and the SR-71 differed considerably. Although three different cameras were developed for the Oxcart program, only the Perkin-Elmer Type I panoramic camera was used during operational missions, equipped with an f/4.0, 18in lens. Two reflecting cube scanners, scanned out to 67 degrees either side of the aircraft's track. Ground resolution was 1ft at 80,000ft vertically below the aircraft (nadir), and about 3ft at the outer edges of the image – that's 36 miles left or right of the Oxcart's track.

Early in its operational history, the SR-71 carried two Itek HR-9085 Operational Objective Cameras, each equipped with a 13in focal length lens. However, these became redundant when, in 1973, Itek delivered a panoramic Optical Bar Camera (OBC), equipped with a 30in lens, which was housed in the aircraft's interchangeable nose section. The high-quality horizon-to-horizon imagery was focused onto fine-grain black and white film with an ISO rating of just 8. This produced an image resolution of less than a foot from 80,000ft at nadir.

A Fairchild Camera Company F489 mounting a 6in focal length lens provided a wide-angle ground-mapping capability that operated throughout the sortie. This enabled photographic interpreters to orientate the position on targets relative to prominent ground features.

The SR-71 could also carry two Hycon HR-308 Technical Objective cameras. These so-called close-look cameras touted a 48in focal length lens and featured a beryllium mirror located in a scan-head whose "squint-angle" could be programmed to seek out targets to the left or right of the SR-71's track. Forward Motion Compensation then ensured that the image was razor sharp by mitigating against platform movement while the shutter was open.

No multi-functional instruments to be seen here; instead the round “steam-dials” of the A-12 betray the true age of the aircraft. The hooded view scope (top center) enabled the pilot to cross-check his position. (Lockheed Martin)

The other major sensor equipping the SR-71 was its high-resolution ground-mapping radar which, like the OBC, was housed in the interchangeable nose section. Initially this was the Goodyear GA-531, with a ground resolution of about 5 feet. It was replaced in the early 1970s by a unit boasting an improved ground resolution and was built by Loral, and referred to as the CAPRE – Capability Reconnaissance Radar. This was replaced in 1984 by the Loral Advanced Synthetic Radar System I (ASARS I), which catapulted radar-generated ground mapping into a new dimension, having a resolution of less than 1ft at nadir from 80,000ft.

ELINT

The A-12 was also equipped with an electronic intelligence (Elint) capability, known as System 6. This wide band collection system comprised a miniaturizing wide-frequency receiver which monitored C, L, X, and P bands. These were then split and recorded by two three-channel recorders working at 2¼in per second; C and X band information, together with capture time and left or right of track directional information, was channeled to one recorder, while the same data for L and P bands was stored by the other unit.

The electromagnetic reconnaissance system deployed on the SR-71 was an automatic, passive collection system that performed two search functions simultaneously – special search and general search. Special search was based upon pre-flight instructions that designated emitters of special interest. Once received the signals were recorded as video signals that were evaluated by specialists after landing. The general search function recorded signal characteristics between 30MHz and 40GHz, thereby capturing any new developments that might require further investigation.

ECM

The various elements of the Electronic Counter Measures (ECM) suite were given cryptic names. “Pin Peg” was a Radar Homing and Warning Receiver (RHAW), and monitored S and C band frequencies, to indicate the presence and approximate position of Fan Song SA-2 target acquisition radars; if required, it also activated the jammer. “Blue Dog II” was the hardware that provided Oxcart with the protective element of the ECM suite. It was a large, deceptive radar countermeasure system, weighing in at 480lb, and

requiring a power output of 20kw and antenna gain greater than 79 decibel megawatts. Utilizing a technique known as range gate pull off, it deceived the SA-2's missile guidance system by generating false guidance commands. Pin Peg and Blue Dog II were used in association with either "Big Blast" or "Mad Moth." The former also covered both S and C bands, generating, when required, barrage and deceptive noise protection against SA-2s, while Mad Moth provided protection in S and C bands against SA-2s by using angle deception.

Due to its time in operational service, the SR-71's ECM, or Defense Electronic (DEF), system was being constantly upgraded as new threats emerged. An arbitrary alpha-numeric system was used to identify equipment fit, and at the time of its retirement in November 1989 the SR-71 carried systems A2, C2, H, and M. Specific details about each system's capabilities remain classified; however, it has been possible to piece together a broad outline.

The SR-71 didn't require electronic defense protection against fighters until the big MiGs (MiG-25 and later the MiG-31) arrived on the scene in the early 1970s. A2 was an ECM jammer designed to protect the aircraft against airborne threats operating in the X-band frequency. Receiving antennas are located in "blisters" located either side of the pitot tube. DEF C2 worked in conjunction with DEF H and provided protection against the SAM threat. On receipt of a signal from DEF C2, the DEF H system was triggered into operation. DEF H weighed in at 900lb and was a barrage noise jammer. DEF M was a deceptive repeater jammer using either range gate pull-off or velocity gate pull-off techniques to protect against the SAM threat.

CREW SURVIVAL SYSTEMS

Emergency escape from any of the Blackbirds was via an ejection seat. But due to the extreme altitudes at which these aircraft flew, pilots were required to wear full pressure suits. In the event of ejection or cockpit decompression,

the suit inflated and provided protection against many physiological problems that, if left unchecked, would kill the crewman in minutes. The multilayered suits were tailor-made for each Oxcart pilot and manufactured by the David Clark Company, Worcester, Massachusetts. They were designated S-901A through to H, and initially featured an aluminum coverall which was later changed to white, in order to reduce unwanted reflections within the cockpit.

By 1977 the David Clark Company had developed the S-1030 suit which was more durable, colored “Old Gold,” manufactured in 12 different sizes, and assumed the seated position when pressurized to aid cockpit mobility. Each suit cost about $130,000, and an SR-71 crew member was issued with two. They lasted 10–12 years, undergoing a complete strip-down overhaul every five years and a thorough inspection every 90 days or 150 hours.

A-12 OXCART OPERATIONS

Lockheed chief test pilot Lou Schalk completed the A-12's first "official" flight on April 30, 1962. (Lockheed Martin)

The A-12 was flown on its maiden flight by Lockheed chief test pilot Lou Schalk from Area 51 on April 30, 1962; however, because of production problems with the Pratt & Whitney J58 engine the

aircraft was powered by two J75s. On January 15, 1963, the first flight of an A-12 powered by two J58s finally occurred, and by the end of the month ten engines were available and the test program began to gain momentum.

The biggest hurdle facing both test pilots and engineers was perfecting the air induction system, designed to vastly augment engine thrust. To achieve Johnson's design goal of sustained Mach 3.2 flight, the air inlet spike's aft-movement, together with the precise position of various bypass doors, initially had to be programmed manually and extremely accurately by the test team to ensure that the terminal shockwave was situated in exactly the correct position in order to stabilize airflow in the inlet duct for future flights. When these parameters were finally achieved, the A-12's thirst for fuel – particularly during the transonic phase of acceleration, was notably reduced. In all, it took 66 flights to extend Oxcart's speed envelope out from Mach 2.0 to Mach 3.2.

During this period 12 USAF pilots were hired by the CIA on a suspended Air Force contract to fly the aircraft on operation missions, and they became members of the 1129th Special Activities Squadron. When these pilots first saw this amazing aircraft they were eager to confer upon it a worthy nickname. Aware of Lockheed's penchant for christening their aircraft designs with names of celestial bodies – P-80 Shooting Star and F-104 Starfighter, for example – Jack Weeks came up with Cygnus (the Swan), which is the name of a constellation in the Northern Celestial Hemisphere. This was particularly apt for the secretive A-12 program because research astronomers believe that Cygnus may contain one of nature's most mysterious invisible bodies – a black hole.

While work was underway on this tri-sonic hot-rod, the West was stunned when, on May 1, 1960, Francis Gary Powers was shot down by an SA-2 SAM missile while flying a U-2 on a deep-penetration mission of the Soviet Union. Consequently, President Eisenhower promised Premier Khrushchev

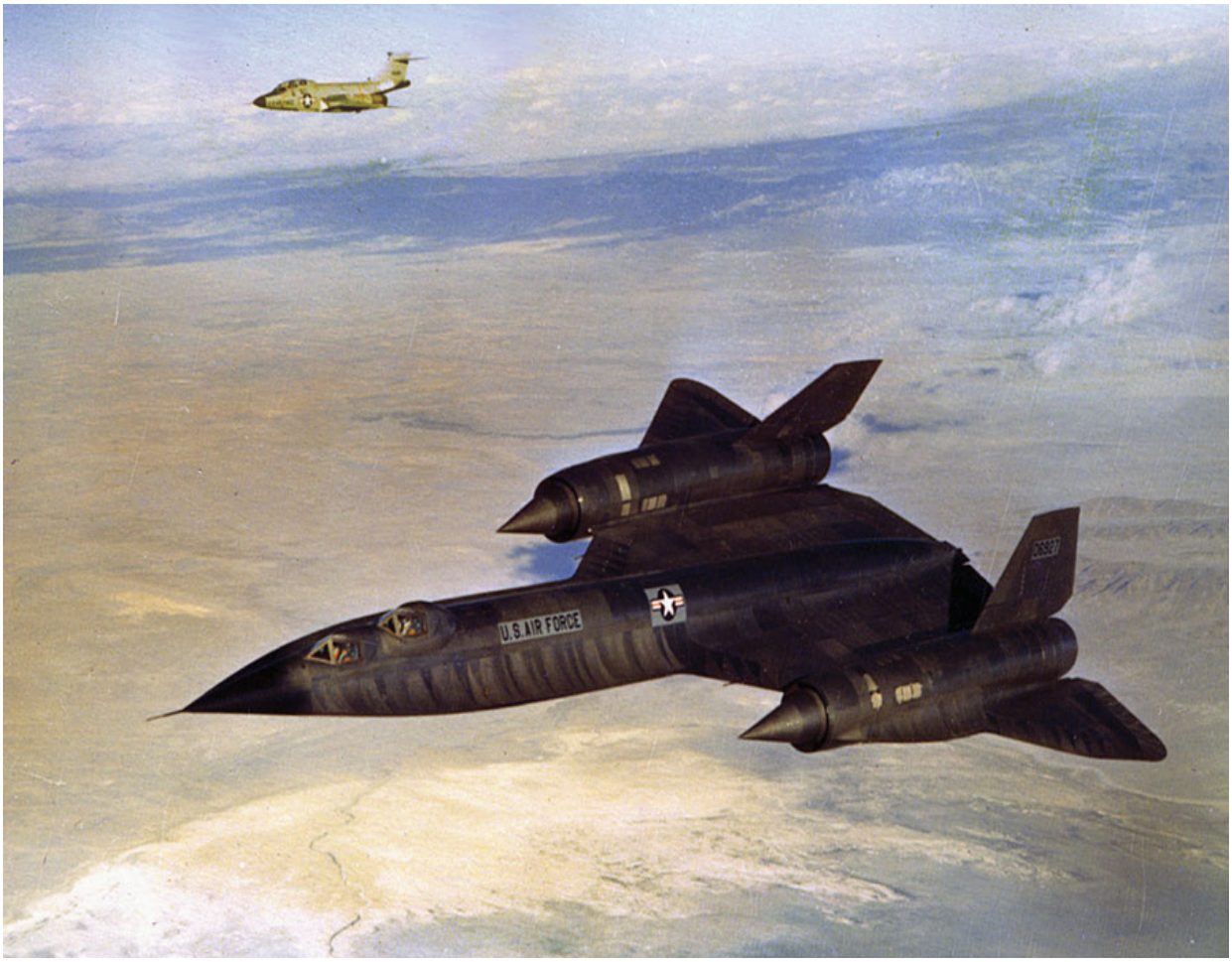
never again to send a manned reconnaissance aircraft on an overflight of the USSR – a promise that has been upheld by every US President since. So the inevitable question arose, “Where can we deploy this multimillion dollar reconnaissance asset?”

By early 1964, Project Headquarters had already begun planning for possible “contingency overflights” of Cuba, under a program codenamed Skylark. Four of the 13 A-12s then at Area 51 were initially designated as primary Skylark aircraft – Articles 125,127,128, and 132 – and they were later joined by aircraft 129 and 131 following the installation of further modifications. However, on September 15, 1966, the 303 Committee (an advisory panel to the President) voted not to commit Oxcart to Cuban reconnaissance missions, on the basis that they might provoke and disturb the prevailing political calm.

LOSSES

As the flight test program geared up, the A-12’s flight envelope continued to expand and the multitude of on-board systems were brought on-line – but success came at a price. On May 24, 1963 the first Cygnus was lost when Ken Collins was forced to eject from aircraft number three (Article 123), during a subsonic engine test sortie, following an aircraft pitch-up and subsequent loss of control. The cause was found to be ice encrustation in the pitot static system, leading to the display of erroneous flight data. Article 133 was lost on July 9, 1964, just as Lockheed test pilot Bill Park was turning onto his final approach into Area 51 having completed a tri-sonic test flight. The aircraft experienced a complete flight control lock-up and Park was forced to eject at about 200kts as the aircraft continued to increase its bank-angle at just 200ft above the desert floor – cause, loss of hydraulic fluid to the flight control system.

Seen here with a CIA U-2 displaying bogus civilian registration markings, Francis Gary Powers was shot down by a SAM during a deep penetration reconnaissance flight of the Soviet Union on May 1, 1960. (Lockheed Martin)



The AT-12 trainer together with an F-101 Voodoo chase aircraft are seen within the Yuletide Special Rules Area (SRA), which was maintained specifically for the A-12s flying out of Area 51. The SRA was enormous, extending from 24,000ft up to 60,000ft and included within it two air refueling tracks. (Lockheed Martin)

On December 28, 1964, agency pilot Mele Vojvodich taxied Article 126 out for a Functional Check Flight (FCF), after the aircraft had undergone deep maintenance. With both burners lit and immediately upon rotating the aircraft, it yawed viciously to one side; corrective rudder application caused 126 to pitch-up. It became apparent that all pilot control inputs were having a reverse effect to those intended – in the midst of these uncontrollable divergent effects, Vojvodich was forced to eject from the aircraft not even 100ft above the ground. With just one swing under the open 'chute, Mele

narrowly missed the flaming pyre of 126, which signified the end of yet another aircraft. The sortie had lasted just 6 seconds, the shortest of any Blackbird flight. A subsequent enquiry established that the Stability Augmentation System had been wired back into the aircraft incorrectly.

On November 20, 1965, Bill Park completed the final stage of project Silver Javelin, the Oxcart validation process, with a maximum-endurance flight of 6 hours and 20 minutes, during which time he demonstrated sustained speeds above Mach 3.2 at altitudes approaching 90,000ft. To further underwrite the A-12's capability to carry out long-range reconnaissance missions, Bill Park completed yet another non-stop sortie, this time of 10,200 miles in just over 6 hours on December 21, 1966. But misfortune struck the program on January 5, 1967, when, due to a faulty fuel gauge Article 125 was lost some 70 miles short of Area 51. The CIA pilot Walt Ray ejected safely, but tragically was unable to gain seat-separation and was killed on impact with the ground.

Clarity of the area-coverage taken by the Perkin-Elmer Type 1 camera when installed in the A-12 was breathtaking. This frame, analyzed by photo interpreters at the National Photographic Interpretation Center, was taken during mission BX6706 on June 30, 1967, by Jack Weeks flying Article 129 at 82,000ft. The resolution is such that it was possible to enlarge areas of the frame many times to identify two Mil Mi-22 Hook helicopters. (CIA via David Robarge)

VIETNAM

As US forces became increasingly embroiled in the Vietnam conflict, the CIA made repeated requests to the President's secretive 303 Committee to deploy a small number of Oxcarts to the Japanese island of Okinawa. The U-2 faced increased risk of attack from SA-2s when flying in the vicinity of Hanoi, but it wasn't until intelligence reports were received indicating that North Vietnam was about to receive STS ballistic missiles, that the CIA finally received approval to deploy Oxcart to Kadena AB, Okinawa. So it was in May 1967 that Operation Blackshield got underway.

With the base made ready to receive its latest guests, the first of three Cygnus aircraft deployed from Area 51 to Kadena AB on May 22, 1967. The transcontinental flight lasted just over 6 hours (this included three air refuelings from US Air Force KC-135Q tankers), and were it not for the fact that Oxcart was highly classified, the trans-Pacific flight would easily have qualified as a world speed record over a recognized course! Seven days later, on May 29, all three A-12s (Article numbers 127, 129, and 131, AF serials 60-6930, 60-6932, and 60-6937 respectively), had arrived safely and Blackshield was declared ready for operations.

The first operational mission (coded BX001), took place on May 31, 1967. Taking off in torrential rain, Mele Vojvodich first topped-off Article number 131, from a KC-135Q tanker in the Deep Work refueling track, just southwest of Okinawa, before accelerating and climbing to Mach 3 and 80,000ft, entering hostile airspace over Haiphong. This so-called "front door" entry then proceeded west over Hanoi before exiting North Vietnam near Dien Bien Phu. A second air refueling (A/R) took place in the Scope Pearl A/R track over Thailand, before another climb and acceleration was completed and a second penetration of "the North" made near the Demilitarized Zone (DMZ). Mele Vojvodich then safely recovered Article 131 back at Kadena following three approaches in driving rain. The film was downloaded from the Perkin-Elmer Type 1 camera and flown by special courier aircraft to the Eastman Kodak plant in Rochester, New York, for processing. The processed imagery was then sent to photo interpreters at the National Photographic Interpretation Center, located within the Washington Navy Yard, Virginia, who prepared the Initial Photographic Intelligence Report (IPIR). The results were astonishing, in all ten priority target categories, including 70 of the 190 known SAM sites, had been successfully photographed.

During its first three months Blackshield successfully completed nine operational missions. According to a CIA report, mission BX6705 flown by Jack Layton in Article 127 on June 20, 1967, was the first Oxcart to be successfully tracked by an enemy's target acquisition radar. This must have caused considerable consternation both back at CIA headquarters and within the Skunk Works, bearing in mind the cost in terms of both time and money that had been invested in reducing the aircraft's RCS.

During Blackshield mission BX6734, on October 30,1967, A-12 Article 129 was being flown over Hanoi, North Vietnam by Dennis Sullivan when it was subjected to a concerted SA-2 attack. The Type 1 camera carried by his Oxcart captured no fewer than six SA-2 contrails on film, and post-flight inspection revealed that a tiny piece of shrapnel had actually penetrated the aircraft's lower wing fillet and had become lodged against a support strut of the wing tank. This "close shave" would prove to be the nearest that any

Blackbird would ever come to being shot down throughout its entire operating career.

During Blackshield mission BX6732 on October 28, 1967, Dennis Sullivan became the first Oxcart pilot to have definitely been attacked by an SA-2 SAM. Two days later, during BX6734 he was again attacked, this time by at least six SA-2s fired by the North Vietnamese. (CIA)

By mid-July, Blackshield imagery had determined that there were no STS missiles in North Vietnam. But by then Oxcart flights were becoming invaluable, providing important intelligence to mission planners concerning the enemy's Order of Battle and high-quality bomb damage assessment imagery. The problem was the protracted timelines between film download

and receipt of the IPIR. As a consequence the 67th Reconnaissance Technical Squadron, at Yokota AB, Japan, received the necessary skills, security clearances, and equipment upgrades to also undertake the work. From August 18, 1967, this enabled the 67th to provide theater commanders with Blackshield imagery and an IPIR within 24 hours of mission completion. Bearing in mind that this all took place well before the age of digitally generated imagery, this was cutting-edge stuff.

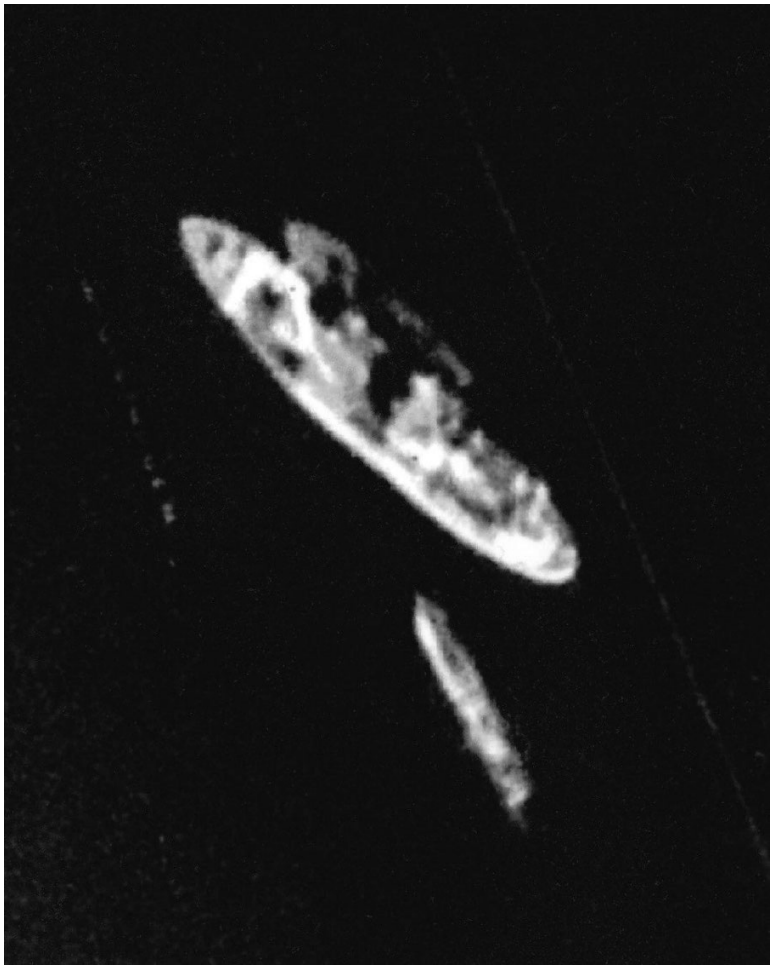
These two images demonstrate how selected areas photographed by the Oxcart's camera can be enlarged in order to gain detailed information. They're part of a frame taken during BX6847 of North Korea, the first image is of Hwangiu Airfield and the second reveals nine MiG-17 "Fresco" fighters parked on the apron adjacent the main runway on the left. (National Archives via Talent-Keyhole.com)

During sortie BX6732, flown in Article 131 by Denny Sullivan on October 28, 1967, the pilot received indications on his RHAW of almost continuous radar activity focused on his A-12, while both inbound and outbound over North Vietnam. This activity culminated in the launch of a single SA-2, the first ever confirmed firing at an Oxcart. Two days later, during the course of sortie BX6734, Sullivan was flying Article 129 high over North Vietnam when, on the first eastbound pass, between Haiphong and Hanoi, his RHAW display indicated that two SA-2 sites were tracking him and preparing to engage but neither launched. However, having completed the air refueling task over Thailand and during the second pass over North Vietnam, while heading west and in the same area as earlier, at least six – and maybe as many as ten – SA-2s were fired from sites around the capital. Looking through his rear-view periscope, Sullivan reported seeing six vapor trails climb to an estimated 90,000ft behind the aircraft and then arc toward it. He then reported observing four missiles, one as close as 100–200 yards away (when flying at speeds of one mile every 1.8 seconds, that's extremely close), and three detonations, all behind the Oxcart. Six missile contrails were captured on the Type 1 camera's film. After recovering the aircraft back at Kadena a tiny piece of shrapnel was found to have penetrated the lower wing fillet, but history would prove this to be the only enemy "damage" inflicted on any Blackbird.

The North's missile activity caused DCI Richard Helms to order the temporary suspension of all Blackshield flights, during which time those involved were given the opportunity to review and re-evaluate procedures and routes. It was more than a month before operational flights resumed, and their reintroduction saw a temporary switch of target areas – for the first time, the "collection area" was Cambodia. Blackshield missions BX 6737 and 6738 both utilized Article 131 and were flown by Mele Vojvodich on December 8, 1967, and by Jack Layton two days later.

On December 15 and 16, overflights of North Vietnam resumed. To limit exposure to the SA-2 risk, mission planners re-orientated the route, moving the east/west track direction, to a less productive south/north route. The next two missions, BX6739 and 6740, both adhered to the amended route and no SA-2s were fired. However, when Jack Layton flew BX6842, reverting back

to the earlier east/west route, on January 4, 1968, he was attacked by a single SA-2, again during the second pass. The aircraft's ECM equipment – Mad Moth and Blue Dog II – were activated and the missile missed its intended target.



The objective of BX6847 was to try to locate USS Pueblo, which had been seized by North Korean naval vessels while it was gathering Elint and Comint. As can be seen, the mission was accomplished – the A-12's pilot at the time was Jack Weeks. (National Archives via Talent-Keyhole.com)

THE PUEBLO AFFAIR

On January 23, 1968, US Navy, Auxiliary General Environmental Research Ship number 2, the USS Pueblo, was seized by North Korean naval forces while undertaking an Elint and Communications Intelligence (Comint) mission in international waters off the North Korean coastline.

In response, President Johnson summoned his top advisors to a meeting at the White House the very next day, during which it was agreed to alert an Oxcart mission for photo reconnaissance of North Korea. The national leadership needed to know not only the location of the beleaguered vessel, but also if North Korea was planning any form of follow-up ground action against South Korea. A draft CIA plan that had already been formulated to overfly North Korea should the need ever arise was therefore about to be implemented in full. In total, three A-12 sorties were flown as a consequence of the capture of Pueblo. The first of these was BX6847, flown on January 26, 1968, by Jack Weeks in Article 131 – just 24 hours after the ship was captured. The Oxcart was equipped with Pin Peg, Mad Moth, and Blue Dog II ECM defense suite; however, these weren't activated as the North Koreans didn't react to the flight. A System IV Elint recorder hoovered up valuable signals intelligence, but it was the Type 1 camera that really proved its worth. It located Pueblo at anchor some distance away from the harbour area in Wonson Bay, and despite problems with the right engine inlet, Weeks successfully completed all three planned passes over North Korea. The four-hour sortie was characterized as a spectacular success – helped by the fact that 90 percent of North Korea was cloud-free. A declassified critique of the mission noted that 71 of 84 programmed targets were imaged, together with one SAM missile target; 81 of the 126 Committee on Imagery Requirements and Exploitation targets were caught, plus 13 SAM sites (of which 12 were occupied), in addition to pinpointing 752 bonus targets. The report concluded that BX6847 "obtained good baseline coverage of most of North Korea's armed forces, as well as large portions of the transportation system and industrial base" – testament indeed to the platform's outstanding capabilities.

During the first mission following the resumption of Blackshield sorties on their earlier east/west, west/east tracks over Hanoi, Jack Layton was fired upon by a single SA-2 while flying Article 127 (serial 60-2930), on January 4, 1968. The missile was fired while its Fan Song guidance radar was operating in low PRF (Pulse Recurrence Frequency) mode. The missile missed its intended target and according to CIA records, this was the last occasion that an Oxcart was fired upon during its operational career.

On June 5, 1968, Jack Weeks was killed while flying an FCF out of Kadena AB in Article 129 (60-6932). His loss was particularly cruel as the Oxcart program had been canceled and the Cygnus pilots were just awaiting orders to reposition the Blackshield aircraft back to Area 51. (CIA)

A second mission, designated BX6853, consisting of two passes or "photo lines," was flown in Article 127, by Frank Murray on February 19, 1968. Equipped with the same sensors as the previous incursion, 88 percent of the programmed targets were cloud-free; however, this proved not to be the case where Pueblo was concerned, and she remained hidden from 127's prying Type 1 camera.

On May 6, 1968, Jack Layton launched Article 127, on sortie BX6858, and headed out on Oxcart's third mission to North Korea; this would prove to be

the final operational flight of the entire A-12 Oxcart program. The reconnaissance "take" was disappointing in comparison to the earlier two, as 50 percent of the programmed targets were shrouded by cloud and haze, and Layton recovered back at Kadena after a flight lasting 3 hours and 30 minutes.

The procurement of such intelligence was not of direct benefit to Pueblo's crew, who were beaten and not released by their captors until nearly a year had passed. The flights did, however, ascertain that "the North" was not about to follow-up with action south of the DMZ. As for the Oxcart program, political sensitivities ensured that the aircraft would never be authorized to conduct the mission for which it was originally designed, and with the CIA's CORONA, film-return, reconnaissance satellite project becoming ever more reliable, Oxcart had in many ways become "an advanced anachronism." Blackshield demonstrated the value of a "hot-spot, quick-look" manned reconnaissance vehicle and the ability to respond with minimal lead times; but in doing so, Oxcart had in effect become a tactical collection platform in a conventional military conflict – something completely outside the CIA's modus operandi. Such activities were, however, very much within the remit of the USAF's SR-71. Indeed, senior members of the Bureau of the Budget (BoB), had been questioning the necessity of funding both programs since November 1965. Finally, following a protracted fight and despite continued objections raised by DCI Richard Helms, the original decision to terminate Oxcart was reaffirmed on May 16, 1968 by the Secretary of Defense – a decision further endorsed five days later by President Johnson.

But while the Blackshield A-12s were stood down, tragedy once again struck the Oxcart program when, on June 4, 1968, Jack Weeks left Kadena in Article 129, with the intention of conducting an FCF. Having completed a 34,000-pound fuel on-load from a KC-135 tanker, he accelerated and climbed away. Neither the pilot nor aircraft was ever seen again. Birdwatcher – the on-board remote sensor system – transmitted a series of signals back to Kadena, indicating that the aircraft suffered a serious problem with the starboard engine, and it appears that a catastrophic structural failure followed and subsequent aircraft disintegration. Not a trace of wreckage was ever recovered, and it was particularly ironic and an

especially cruel twist of fate to lose such a highly competent and professional pilot on one of the very last flights of the Oxcart program.

In total, of the 63 Blackshield missions that were authorized by project headquarters, 29 were actually flown. The main reason why flights were subsequently scrubbed was invariably poor weather conditions in the collection area.

Once Tagboard and Oxcart had been terminated, the remaining M-12 and eight A-12s were placed in storage at Palmdale, CA. Note the bogus serial applied in red on the tail of Article 131, serial 60-6937, which had been applied during Blackshield. The “US Air Force” titles and star-and-bar were applied after program shut-down. (Lockheed Martin)

TAGBOARD AND SENIOR BOWL, THE M21/D-21

Two A-12s were modified and re-designated M-21s in order to air-launch D-21 drones, following President Eisenhower's commitment never again to violate Soviet airspace with manned reconnaissance-gathering aircraft after the U-2/Gary Powers incident. Article 134 serial 60-6940 is the sole survivor of Project Tagboard. (Lockheed Martin)

TAGBOARD

Following the loss of Powers' U-2 and the US government's decision to discontinue manned overflights of the Soviet Union, the Skunk Works received authorization to begin studies into the feasibility of producing a Mach 3 plus unpiloted platform, or drone, for the CIA on October 10, 1962. Initial flight tests of the A-12 had given the design team working on the drone – designated at this early stage Q-12 – considerable confidence in the aerodynamic precedent set by the chined delta, and this configuration was applied to the vehicle as it solidified. Powered by a high-speed ramjet, the engine was built by Marquardt and designated the XRJ43-MA20S-4. To provide the necessary propulsive power to start the ramjet, the drone would be launched at Mach 3.13 from a modified A-12. Reconfigured for the purpose, a launch control operator was located in what was the A-12's Q bay. Two A-12s were modified for these duties – Articles 134 and 135, serials 60-6940 and 60-6941 respectively, in a project codenamed "Tagboard." This mother-daughter combination gave rise to their redesignation M-21 (Mother) and D-21 (Daughter – drone); the numerical designation was transposed to avoid all confusion with the A-12. The drones were considered "one-way aircraft," meaning that they'd make one flight only, after which the palletized unit containing the platform's INS and reconnaissance camera and film, would be ejected in international waters and recovered during the parachute descent, by a C-130 utilizing a Mid-Air Recovery System. The remainder of the drone would then self-destruct, using a barometric explosive charge, the remains disappearing into the ocean. On August 12, D-21 number 501 was sent from Burbank to Area 51, where satisfactory static tests were concluded. On December 22, 1964, the first D-21/M-21 combination flight was successfully completed. Having surmounted a number of technical difficulties, the two-aircraft combination was flown out to Mach 2.6 in May 1965; however, it wasn't until October 21 of the same year that the team were finally able to get the M-21 up to the required launch speed. This was achieved by installing the new, 34,000-pound thrust J58 engines to the M-21. Delays continued, but finally on March 3, 1966, the first D-21 launch was accomplished – the drone crashing into the Pacific 120 miles after vehicle separation, but at least the launch

technique was successfully demonstrated. The second flight, on April 27, was a brilliant success, the D-21 achieving a range of 1,200 nautical miles – holding course to within half a mile, a speed of Mach 3.3, and an altitude of 90,000ft.

M-21 Article 135 (serial 60-6941) was destroyed during the fourth D-21 launch, when the drone collided with its mothership during the separation maneuver. Both crewmen ejected safely over the Pacific, but tragically LCO Ray Torick then drowned when his pressure suit filled with water.

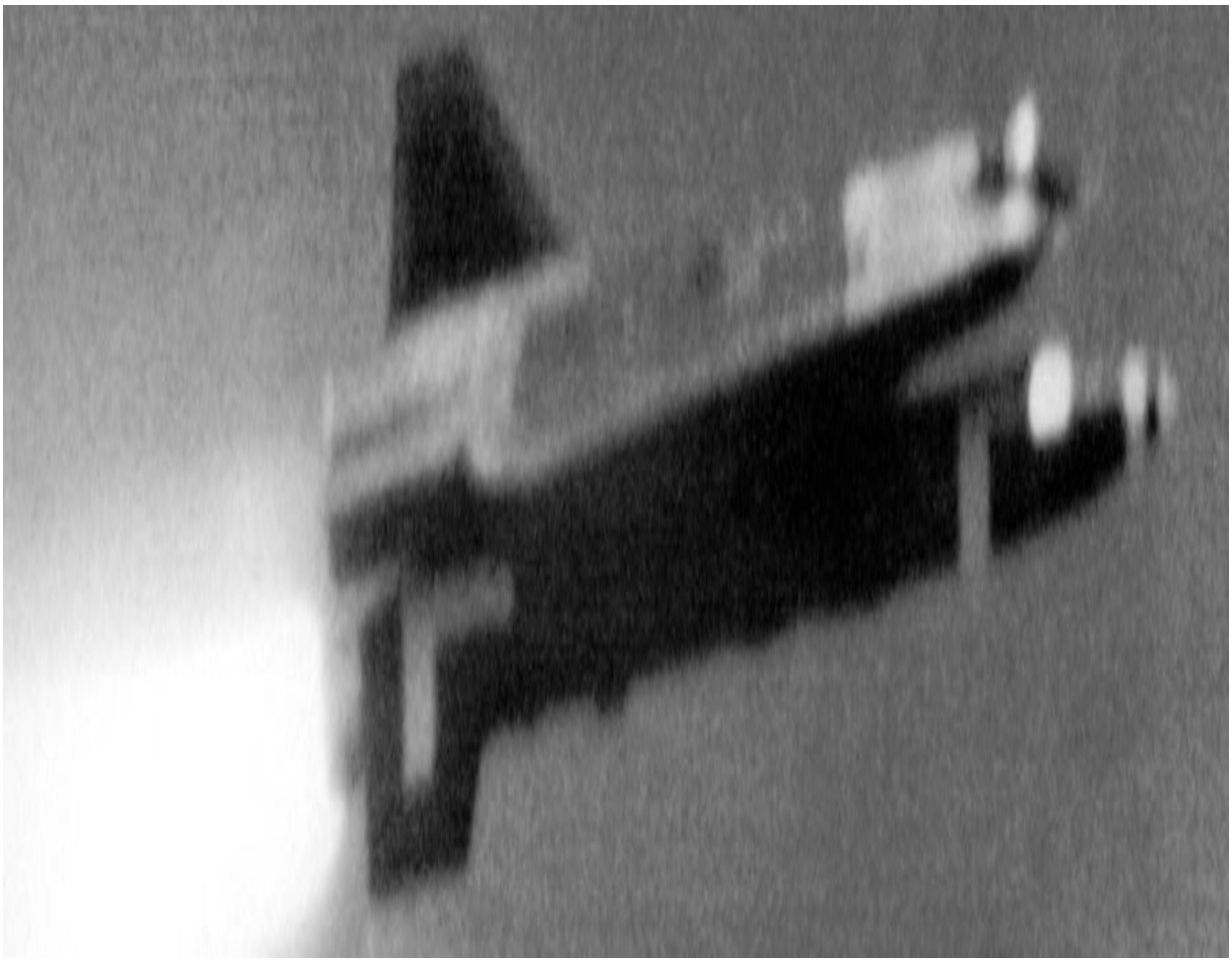
A second drone order was placed on April 29 for 15 D-21s. However, Kelly formally proposed that SAC should launch the drone from a B-52H, and that the drone use a rocket booster to propel it to ramjet speed and altitude. The

proposal was made on the basis of “greater safety, lower cost and greater deployment range” – this proved prophetic.

The third launch, on June 16, went well, with the drone clocking up 1,600 nautical miles and completing eight programmed turns. However, disaster struck on July 30, when, during the course of the fourth flight, D-21 number 504 collided with M-21 Article 135, serial 60-6941, during the separation maneuver. At Mach 3.25 the M-21 pitched up, the aircraft’s forward forebody broke off, and despite both crew members successfully ejecting, the LCO Ray Torick tragically drowned in the subsequent feet-wet landing.

The D-21 was almost 43ft long, with a wing span approaching 20 feet. Its maximum gross take-off weight was 11,000lb, which included the recoverable reconnaissance hatch that carried the high-resolution Hycon HR-355 camera.

Following a meeting in Washington on August 15, 1966, it was decided to cancel Tagboard. During the subsequent D-21 grounding that lasted a year, a new program codenamed Senior Bowl was initiated. Two B-52Hs belonging to the 4200th Test Wing at Beale AFB were converted to provide a launch platform. The D-21s (as envisaged earlier by Kelly), utilized a rocket booster, to blast the drone to speed and altitude before separating and falling to the ocean. However, like Tagboard, results from Senior Bowl were at best questionable. The program was canceled on July 23, 1971, by which time satellites were proving to be far more reliable and cost efficient.



To start the D-21B's ramjet when launched from a B-52 it was necessary to use a rocket booster to accelerate the platform to 80,000ft and Mach 3.2.

Once the ramjet was started the depleted rocket was jettisoned and allowed to fall into the ocean. (Lockheed Martin)

Following the loss of Article 135, Project Senior Bowl utilized two modified B-52Hs from which to launch the D-21Bs. (Lockheed Martin)

KEDLOCK, THE YF-12A

Prototype AF-12/YF-12A serial 60-6934, Article 1001, is seen on an early test flight. Note the streamlined camera pods to record weapons separation and the extended centerline fin to increase longitudinal stability. (Lockheed Martin)

During the late 1950s a specification was drawn up to provide a fire control and missile system for the North American F-108 Rapier interceptor. Its

ASG-18 pulse-Doppler radar system, developed in parallel with the GAR-9 missile by Hughes, would have a look-down/shoot-down capability for head-on attacks. This radar system considerably advanced the maximum range of contemporary airborne intercept mono-pulse systems then in use from 40 miles to 120 miles.

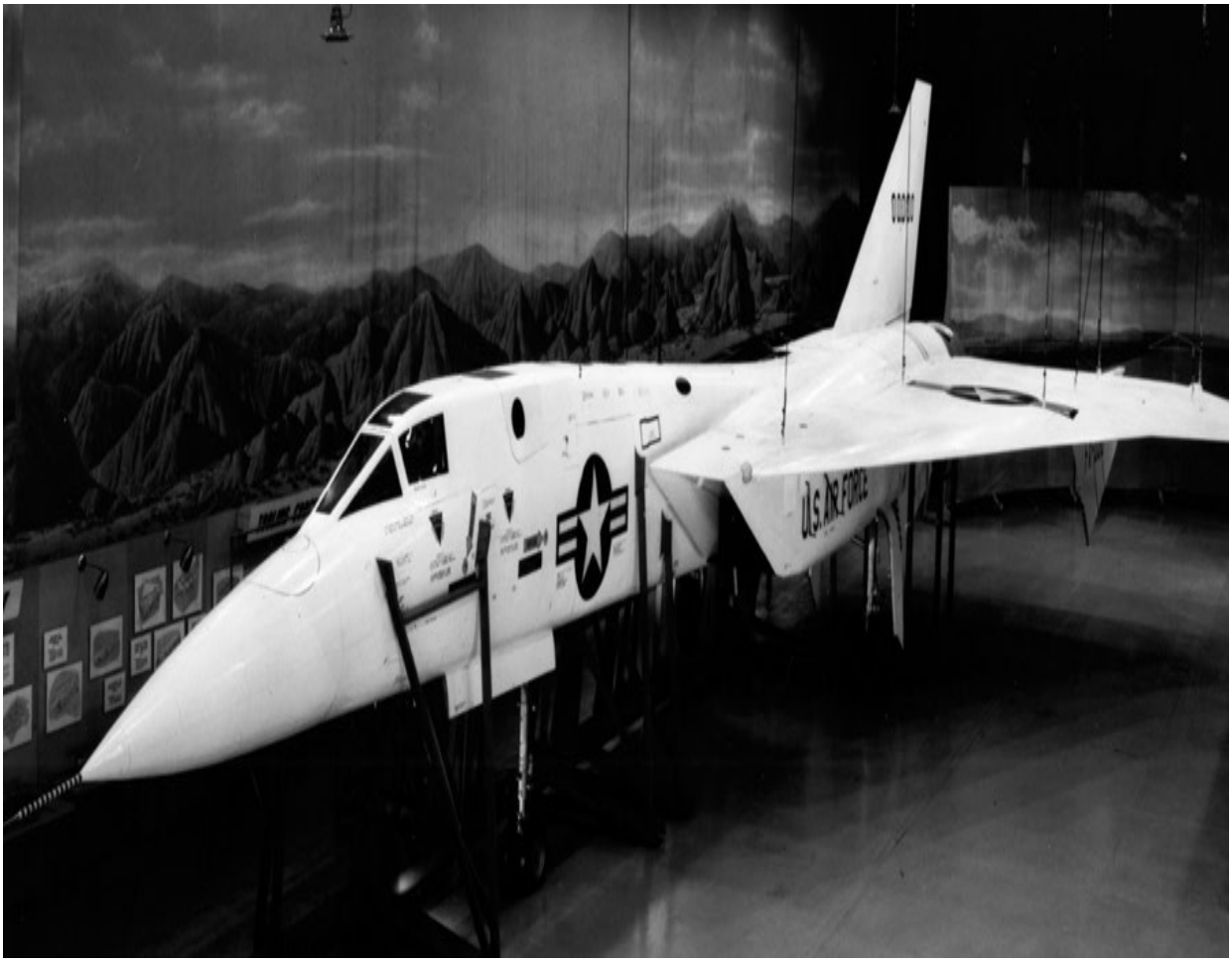
As development of both aircraft and avionics progressed, a Convair B-58 was bailed to Hughes to act as a systems test-bed. Delivered to the Hughes main plant at Culver City, California, it was on the ground in excess of a year while reconfiguring work prepared it for the missile and Fire Control System (FCS) flight test program. While this was being undertaken, Hughes engineers were using high-speed film techniques and a 9ft deep pit, filled with foam, to analyze separation and pitch characteristics of the 818lb missile. Missile/vehicle separation was provided by two thrusters, one located at each end of the missile. On firing, these propulsive charges unlocked the missile from its rail, then forced the missile down, clear of the aircraft. At a finite time, its rocket motor ignited and the GAR-9 sped away.

In 1961, with work progressing well, Hughes appointed James D. Eastham as project test pilot on the YB-58 ASG-18/GAR-9 program. Hughes also provided the Fire Control Operators (FCO), two of whom would occupy the tandem positions behind Eastham. Their task was to monitor the entire system and fire the GAR-9.

On completion of modifications to the YB-58, the program was moved to the Hughes facility on Contractors Row at Edwards AFB, California. Despite the cancellation of the F-108 program on September 23, 1959, Department of Defense officials decided that the outstanding FCS and missile development program should continue on a “stand-alone” basis.

Spurred on by the earlier success of his A-12 design for the CIA, Kelly Johnson discussed the possibility of building a long-range interceptor version for the Air Force, during a meeting on March 16/17, 1960, with General Hal Estes of Air Force Systems Command and Dr. Courtland Perkins, the Air Force Secretary for Research and Development. Referred to as the AF-12, the idea was keenly received and subsequently forwarded to General Martin Demler at Wright Patterson, for further discussion and analysis. During late October 1960, Lockheed received a letter of intent for $1 million and was directed to "go forward with Plan 3A" and produce an interceptor version of the A-12. Furthermore, it was stipulated that the aircraft was to be equipped with the Hughes ASG-18 FCS and the GAR-9 missile system. The program was accorded the classified cryptonym Kedlock, and the seventh A-12 was nominated to become the AF-12 prototype. In December 1960, a second project group working on Kedlock was organized at Lockheed's Skunk Works, and to maintain security it worked independently of the A-12, Oxcart team.

A considerable amount of work was necessary to convert the reconnaissance platform into an interceptor, with most of this being focused around the forebody, forward from fuselage station 715. Initially these external changes were typified by the creation of a second cockpit in what was the A-12's Q-bay; the fuselage "chines" were cut back to incorporate a radome to house a 40in scanning dish; and four weapons bays cut into the underside of the "chines," to house the FCS (in the right, forward bay), and three GAR-9 missiles – two in the left bays, and the third in the right rear bay.



The North American F-108 Rapier only made it to the mock-up stage before being canceled. (Rockwell International)

Work seemed to be progressing well; however, by June, wind tunnel tests revealed serious directional stability problems resulting from the reconfigured nose section. To alleviate the problem two fixed ventral fins were installed on the underside of each engine nacelle; in addition a large folding fin was mounted on the underside centerline of the aircraft's rear fuselage. Retraction and extension of the folding ventral fin worked out of phase with the cycling of the landing gear – in short, when the gear was retracted, the fin extended and vice versa.

Convair YB-58A Hustler nicknamed “Snoopy” – note elongated nose – was modified and used to undertake trials on the AN/ASG-18/GAR-9 fire control and missile system. Also note the single GAR-9 missile extended from the external weapons pod. (Jim Eastham)

By August 2, 1962, Air Force funding had been increased to allow for the modification of three A-12s, and major sections of the prototype, assigned the Lockheed Article number 1001 and Air Force serial 60-6934, were in the jig at the Skunk Works. As the manufacturing effort continued, from December 1962 through to the spring, reservations were mooted in some quarters about the security of both the Oxcart and Kedlock programs, particularly in relation to the latter’s fast-approaching flight test program. Edwards AFB certainly appeared to offer the best option; however, in the event 1001 was crated up and trucked to Area 51.

OUTLINE DESCRIPTION

The YF-12A was 101.66ft long, stood 18.38ft high, had a wingspan of 55.62ft, and a wing area of 1,605 square feet. Empty gross weight of the prototype was 60,730lb, the specification being 59,422lb, and the maximum take-off weight, again for the prototype, was 127,000lb; the spec. was 124,491lb. On the ground, the aircraft was supported by a tri-cycle undercarriage, which had a main-wheel base of 37.8ft. Interestingly, the aircraft's maximum allowable airspeed and its design speed were one and the same, 450 Knots Equivalent Airspeed (KEAS). The expression "KEAS" was used throughout the A-12/YF-12 and SR-71 programs when speed criteria needed to be followed, because aircraft are designed structurally utilizing KEAS, and it also enabled one airspeed limit to be specified for all altitudes.

The AN/ASG-18 is one of the largest radars ever fitted to a fighter. Note the forward-facing infrared sensors; one was mounted each side of the cockpit in the shoulder of the fuselage chine. (Lockheed Martin)

Jim Eastham completed the prototype AF-12's first flight from Area 51 on August 7, 1963 – he was chased by Lou Schalk in an F-104 Starfighter. (Lockheed Martin)

PREPARATIONS FOR FLIGHT

Once article 1001 had arrived at Area 51, several weeks were spent reassembling the aircraft, equipping it with twin Pratt & Whitney J58 engines, and completing a high-speed taxi test to near take-off speed. On August 7, 1963, Jim Eastham climbed aboard 60-6934 for a first flight which

he later modestly characterized as a typical production test flight. Kelly Johnson would later note in his AF-12 log, “It is the first airplane I’ve ever worked on where the fire control system was checked out prior to the first flight.” Having completed its maiden flight with flying colors, there was little urgency in getting the YF-12A out to its design speed of Mach 3.2, since the full speed envelope had already been achieved with Oxcart. Instead, time was spent installing the fire control system, ensuring that it integrated into the YF-12, and testing the inertial navigation system.

GOING PUBLIC

With the Oxcart flight test program now in full swing at Area 51, the increase in test and training sorties brought with it an increase in the number of sightings made by airliner crews and others outside the program. This led to questions being raised as to how much longer the project could remain hidden. On November 29, 1963, one week after the assassination of President Kennedy, the new President, Lyndon B. Johnson, convened a meeting of the National Security Council, the main question on the agenda being whether to, or how to, “surface” the technological triumph of Oxcart. In the event, it was decided to keep the program secret until the run up to the 1964 elections. However, after the Republicans accused the Democrats of failing to sponsor new aircraft projects, Johnson directed his advisors to prepare a formal announcement about the hitherto black world project. Kelly Johnson was asked to work on the draft, and he proposed that the terminology “A-11” be used in the statement, as “it was the non-anti-radar version” – which didn’t get built. President Johnson announced the existence of the A-12 on February 29, 1964, using the “A-11” designation in his speech as recommended by Kelly Johnson.

To give credence to the President’s announcement and divert attention away from the CIA’s Oxcart program at Area 51, two YF-12A aircraft, 60-6934 and 60-6935, were positioned to Edwards AFB by Lou Schalk and Bob Gilliland (Gilliland would become chief test pilot of the SR-71). The event

was witnessed by just a few dozen maintenance staff who happened to be at work that Saturday morning. Aircraft 60-6936 joined its two stablemates at Edwards a few weeks later.

Once at Edwards the number of people assigned to Kedlock ballooned to include personnel from Air Force Systems Command and Air Defense Command (ADC). Work at the new base wasn't without its difficulties, as most of the expertise remained at Area 51 with Oxcart. Notwithstanding, once a new electrically controlled air inlet system had been installed to reliably control airflow within the aircraft's air inlet, it took Eastham just three months to complete the YF-12's envelope extension program – all of which were conducted in the Lockheed-operated prototype, 60-6934.

With much of the "pick and shovel work" completed in the B-58, the ASG-18 and the GAR-9 (now redesignated the AIM-47 Air Intercept Missile), were quickly integrated into the YF-12, where the system transcended its predicted performance figures. Once in operational service, three AIM-47s were to be hauled aloft; however, the highly instrumented test aircraft never carried the planned full missile load.

Although the GAR-9/AIM-47 radar-guided missile (seen here on the trolley) never entered service, it provided much of the technology used in the legendary AIM-54 Phoenix missile, which was used to great effect by the US Navy's F-14 Tomcats. (Lockheed Martin)

The YF-12 interceptor's cockpit canopy was higher than that of the single seat A-12, due to the slightly wider forward fuselage to accommodate the large radar scanning dish housed within the radome. It was equipped with the very long range AIM-47 Falcon missile (later to be developed into the naval AIM-54 Phoenix) and Hughes AN/ASG 18 fire control system, both of which had been developed for the canceled XF-108 Rapier

An indication of the system's operational potential can be gauged from a test flight flown on April 25, 1966, in '934, from Eglin AFB, Florida, over the Gulf of Mexico, as Jim Eastham recalls:

Following take off, we accelerated in a generally southwest direction and made a right turn onto an east bound heading for the “hot-run.” George Parsons my FCO acquired the target, which was at about 1,000ft, Mach 0.6 and heading west at a range of 130 nautical miles. At that time we were at Mach 3.2 and 75,000ft. Even though we were being vectored, we also ran the mission utilizing a modified close-control feature of the ASG-18 weapon system and tracked the target at the exact 12 o’clock position. Our closure rate was Mach 3.8 and essentially we had an altitude differential of 75,000ft! We went through the mission prep stage and the launch was made at approximately 53 nautical miles. The missile guided to impact on the left horizontal stabilizer of the QB-47. At the time of impact we were looking down 73 degrees at the target!

On May 1, 1965, exactly five years after the Gary Powers/Lockheed U-2 shoot-down, YF-12A 60-6936 was flown by two USAF crews and established four World Absolute Speed and Altitude Records. The large white cross applied to the aircraft's underside assisted powerful ground-based cameras to monitor the flights. (Lockheed Martin)

Date	Mission Number	YF-12	Speed	Altitude	Target	Target Altitude
March, 18,1965	G-11	935	M2.2	65k	Q-2C	40k
May, 19,1965	G-13	935	M2.3	65k	Q-2C	20k
September, 28,1965	G-15	934	M3.2	75k	Q-2C	20k
March, 22,1966	G-18	936	M3.15	74.5k	Q-2C	1.5k
April, 25,1966	G-19	934	M3.2	75k	QB-47	1.5k
May, 13,1966	G-16	936	M3.17	74k	Q-2C	20k
September, 21,1966	G-20	936	M3.2	74k	QB-47	Terrain

The unarmed missile hit and destroyed approximately 4ft of the B-47's horizontal stabilizer. It seems that all but one of the seven launches made by the Lockheed crew were deemed to be a success – the failure of one was attributed to a missile gyro system failure. ADC were extremely impressed and calculated that it required 96 production versions of the big fighter – designated F-12B – to replace its aging fleet of F-102 and F-106 interceptors. With a force this size, officials were confident that they could provide protection to the entire United States against incoming high-speed,

low-level bombers by stationing three squadrons of 16 aircraft each on the east coast at Otis AFB, Maryland, and another three squadrons at Paine AFB, Washington, to protect the west coast. However, Secretary of Defense Robert McNamara preferred the so-called F-106X proposal (which would metamorphose into the F-15 Eagle), after a national intelligence estimate showed it to be the most cost-effective answer to the predicted Soviet bomber threat. As a result, on three separate occasions over three years, he denied the Air Force access to $90 million worth of funds that had been appropriated by Congress to begin F-12B production.

Finally, on January 5, 1968, the Skunk Works received official notification from the Air Force, closing down the F-12B. The YF-12A program formally ended on February 1. This was followed up four days later by a letter from the Air Force instructing Lockheed to destroy all A-12/F-12 and SR-71 tooling. In compliance, the large jigs were cut up and sold for scrap and Kelly Johnson noted in his log, “Ten years from now the country will be very sorry for taking this decision of stopping production on the whole Mach 3 series of aircraft in the USA.”

SENIOR CROWN, THE SR-71

SR-71A 61-7955, Article 2006, was used extensively by AFLC Det 51/6 at Palmdale as the dedicated SR-71 test aircraft. It undertook its last flight on January 24, 1985. (Lockheed Martin)

On September 14, 1960, encouraged by the success of his earlier A-12 reconnaissance design for the CIA and the YF-12A interceptor proposal for the

Air Force, Kelly Johnson began work on a reconnaissance bomber version of the basic design that he called the RB-12 (RB for "Reconnaissance Bomber"). In January 1961 he took his unsolicited proposal to Washington and dropped it on the desk of Under Secretary of the Air Force, Dr. Joseph Charyk.

Charyk instructed his team at the Air Development Center located at Wright Field, Ohio, to conduct an engineering analysis of the proposal. Just ten weeks later the team took their counter-proposal that they referred to as the RS-12 (RS for "Reconnaissance Strike") back to Charyk, who liked what he saw and instructed them to present it to the Skunk Works boss at Burbank. To his enormous credit, Kelly too was extremely impressed with how the team had enhanced the capability of his original design and, as a result, shelved his RB-12 proposal in favor of the team's RS-12 design.

It was proposed that each RS-12 would carry internally a single nuclear weapon, equipped with an adaptation of the Polaris A-3, single megaton warhead. As part of Strategic Air Command's (SAC's) Single Integrated Operational Plan, to be implemented in the event of a nuclear war, the RS-12's concept of operations would require the aircraft to penetrate enemy airspace at Mach 3.2 and 80,000ft and use its radar to search designated areas, locate, then identify and strike selected targets. Utilizing its GAM-87 Astro-inertial Navigation System (ANS) – destined to equip the SR-71, which had been developed for the subsequently canceled Skybolt ballistic missile – the Air Force and Skunk Works teams confidently predicted that an RS-12, with an all-weather radar-guided missile, would be capable of hitting its target within a 50ft circular error of probability, when launched from an altitude of 80,000ft and a distance of 50 miles.

The MiG-31 (seen here) and its predecessor the MiG-25 were both high-speed, high-altitude interceptors designed specifically to take on the B-70 Valkyrie bomber and A-12/SR-71. When the former was canceled, only SR-71 crews saw this adversary operationally and all were confident that the "big MiGs" did not represent a credible threat. (Yefim Gordon)

A Class 1 mock-up of the forward forebody of the RS-12 was built at Burbank, and on June 4, 1962, this was satisfactorily reviewed by a number of senior Air Force officers. However, a firm commitment to order was never forthcoming. The problem was that the ballistic missile had come of age and doubt was being expressed about the long-term viability of bombers as a delivery platform for nuclear weapons. President John F. Kennedy had canceled the proposed high-profile multimillion dollar B-70 Valkyrie bomber on March 28, 1961 (only two prototypes were built for research and

development purposes and one was lost following a mid-air collision in 1966). The upshot of all this was that the RS-12 was never funded and consequently came to nothing. Undaunted, Johnson submitted yet another unsolicited bomber proposal, as late as April 1965, which he referred to in-house as the B-71, but this too remained a “paper only aircraft.”

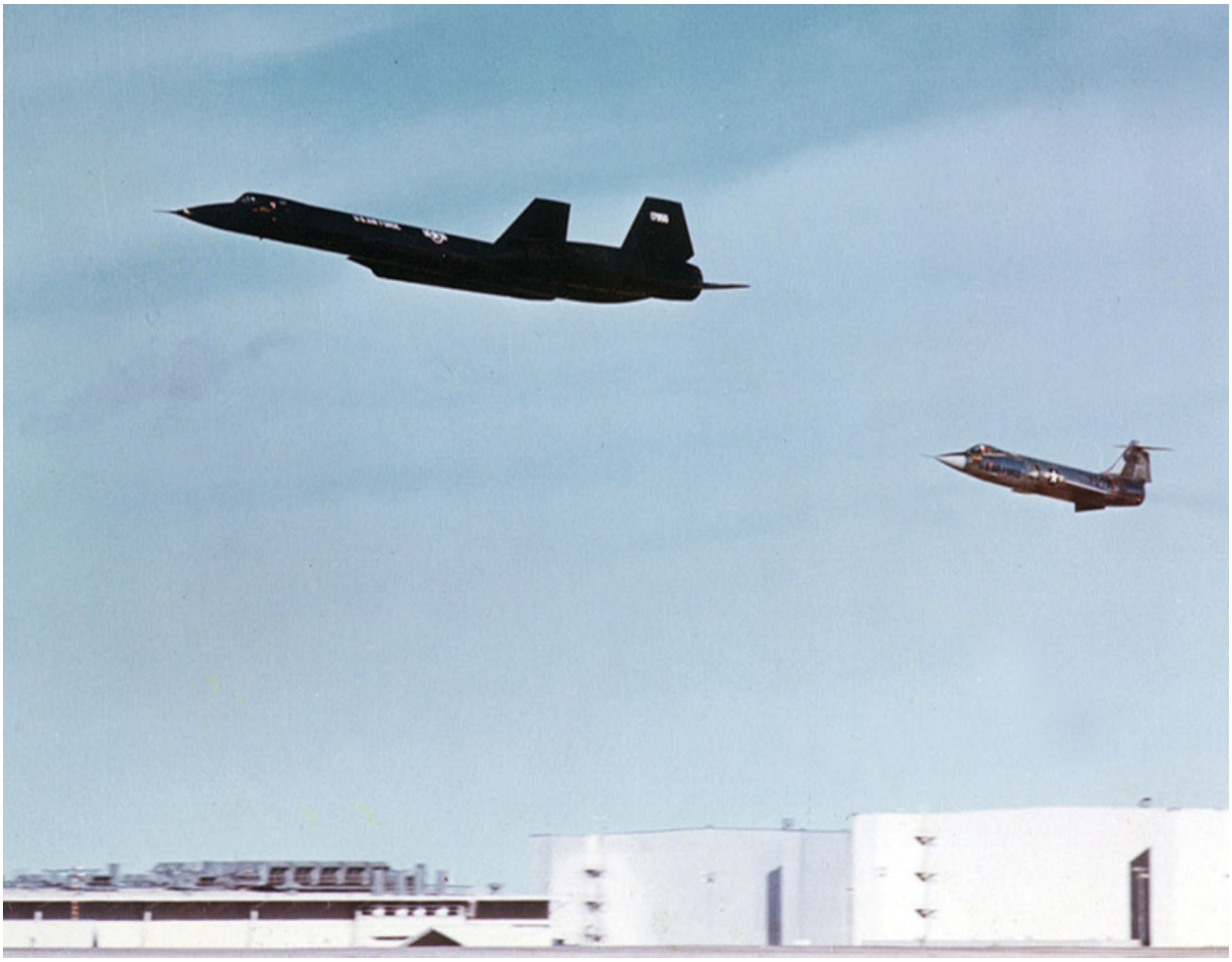
All SR-71s were trucked from the Skunk Work’s Burbank manufacturing site to Site 2, Air Force Plant 42, Building 210 at Palmdale, California. (Lockheed Martin)

On December 6, 1962 Kelly Johnson began drawing up an aircraft he referred to as the R-12 Universal airplane. Johnson’s rationale for this design was based on the premise that if he produced a single platform capable of

performing the reconnaissance, recon/strike or intercept role, depending on customer needs, it would greatly simplify production and eliminate the necessity of the Air Force deciding which specific version they wanted to buy. One week later, on December 20, Kelly and several of his engineers flew to Washington to continue their contract pursuit. The R-12 was presented to the Air Force in a closed session the next day, after which Johnson was informed that the proposed aircraft was too heavy and needed to be scaled down to 1,500lb of payload.

Further design refinements of the R-12 continued, and these were finally rewarded on February 18, 1963, when Lockheed was awarded pre-contractual authority to build six R-12s, on the understanding that an additional 25 would be ordered by July 1. The first mock-up review of the new reconnaissance aircraft took place on June 13/14, 1963, and eventually an agreement was reached, with an aircraft production rate set at one aircraft per month for 31 months. The entire program was completed under budget at a cost of $146 million (approximately $1.5 billion at today's values), which excluded engines and sensors, but included Categories I, II, and III of the flight test program – a remarkable achievement by any standards.

On February 29, 1964, during the run-up to that year's presidential election campaign, and in response to a challenge by Republican candidate Senator Barry Goldwater that the Democrats had neglected the defensive needs of the country, incumbent President Lyndon B. Johnson revealed the existence of the "A-11" [A-12] program. Five months later, on July 25, in yet another piece of electioneering, President Johnson made a second announcement about another hitherto "Black World" aviation program, when he announced the existence of the SR-71 program. This program was accorded the cryptonym Senior Crown, by the Air Force – the first word, Senior, being one that's allocated to special-access required programs, the second word, Crown, being type specific to the SR-71.



Bob Gilliland successfully completed the SR-71's first flight from Palmdale in the prototype, serial 61-7950, Article 2001, on December 22, 1964 – he was chased by Jim Eastham in an F-104 Starfighter. (Lockheed Martin)

On October 29, 1964, two large trailers delivered the prototype SR-71, Lockheed Article number 2001, Air Force serial 61-7950, from Burbank to Site 2, Air Force Plant 42, Building 210, at Palmdale.

Following the Herculean efforts of all involved, Lockheed chief test pilot Bob Gilliland got airborne from Palmdale in '950 using his personal call sign "Dutch 51" on December 22, 1964. For safety reasons, the back seat, which would usually carry either a flight test engineer or an Air Force RSO, remained empty. With much of the ground work already completed by the earlier A-12 and YF-12 test programs, Gilliland was confident enough to

take the aircraft up to 50,000ft and Mach 1.5 on this first flight, which was completed as planned and without incident.

PROGRAM CANCELLATION?

In November 1965, the Bureau of Budget (BoB) voiced concern at the costs associated with running both the covert CIA, A-12 Oxcart program and the USAF "overt" SR-71 Senior Crown program, and recommended the implementation of a drastic cost-cutting exercise. This entailed closing down the A-12 program by September 1966. However, Secretary of Defense Robert McNamara rejected the recommendation on the basis of risk, given that the SR-71 wouldn't be mission-ready by that date. However, six months later, a study group was set up, and included on the panel were representatives from the BoB, CIA, and Pentagon. It identified three possible alternative courses of action: namely, to continue running both fleets at current levels; mothball all A-12s while sharing SR-71s between the CIA and SAC; or, assuming Senior Crown would be ready for operations, end the Oxcart program in January 1968 and assign all Oxcart missions over to the Air Force. On December 12, 1966, DCI Richard Helms, Deputy Defense Secretary Cyrus Vance, BoB Director Charles Schultze, and presidential scientific advisor Donald Hornig met in Washington and voted three to one that the third option would be recommended to the President – the sole dissenting voice was that of Helms. President Johnson upheld the decision and the CIA began the detailed planning necessary to draw-down Oxcart – even before it had flown a single operational mission! However, as the war in Vietnam escalated, some in the intelligence community claimed that the North Vietnamese were about to deploy surface-to-surface missiles (SSMs). After much prevaricating, on May 16, 1967, the CIA finally received authorization to deploy to the Southeast Asian theater of operations, to verify or dismiss the SSM claims. As covered earlier, personnel, equipment, and three A-12s were flown to Kadena AB, on Okinawa, in support of operation Blackshield – despite the A-12 adhering to a phase-out plan.

By late 1967, on the back of imagery secured by Blackshield, the earlier Oxcart decommission decision was questioned in some influential circles. The A-12 was lighter and therefore could fly higher than its Air Force stablemate. Additionally, its camera package provided superior ground resolution to those being carried by the SR-71 at that time. But the Air Force countered that its platform could carry three different sensor packages, recording simultaneous synoptic coverage of a target area that included Photint, Elint, and, utilizing its powerful ground-mapping radar system – effective through cloud-cover – could also record Radar Intelligence (Radint). To try to resolve the dichotomy, a fly-off, codenamed Nice Girl, was staged. Consequently, between October 20 and November 3, 1967, an example of each aircraft type flew three identical routes along the Mississippi River. Representatives from a number of interested agencies evaluated the data collected, but the results were inconclusive. On May 16, 1968, the decision to end the Oxcart program was reaffirmed and the remaining aircraft were flown into storage at Palmdale. The SR-71 program had prevailed and the Air Force were now the sole operators of a Mach 3 plus reconnaissance aircraft.

FLIGHT TEST

The first six SR-71s to come off the production line were allocated to the flight test program. Aircraft serials 61-7950, ’951, and ’952 were Lockheed test vehicles, while ’953, ’954, and ’955 were allocated to the Air Force. In the 1960s Air Force Regulation 80-14 detailed three distinct phases of an Air Force test program. Category I required the contractor, in this case Lockheed, under close observation of the System Program Office at Wright-Patterson AFB to basically collect and present data to the USAF that proved they were delivering what was ordered; that the aircraft was safe to fly and that its systems functioned in line with the aircraft’s mission. Category II testing required Air Force flight test personnel to utilize and apply data provided by Cat I flight testing into a fully integrated, functioning aircraft system that conformed with Air Force operating procedures. Category III

flight testing was conducted at Beale AFB. Here the operational crews and maintenance teams utilized all the data generated in Cat I and II testing, including flight and maintenance manuals and other support equipment, to ensure that it all worked as required in an operational environment and to identify any areas needing further improvement.

ATTRITION AND LESSONS

Not surprisingly with such an advanced complex aircraft, progress to full operational status didn't come easily or without cost. The first SR-71 loss occurred during a test sortie flown out of Edwards AFB, by Lockheed test pilot Bill Weaver and his flight test engineer Jim Zwayer on January 25, 1966. Aircraft 61-7952 was being flown as per the test card, with its center of gravity positioned further aft than normal to compensate for the rearward shift of the center of pressure encountered at high Mach. This was done in an attempt to reduce trim drag and thereby lower fuel consumption during the transonic phase of flight. But while at 80,000ft, Mach 3.1, and in a 30-degree banked turn to the right, the right inlet unstarted. The cumulative effects of aircraft configuration speed, attitude, and altitude resulted in a violent pitch-up and the aircraft disintegrated. Miraculously Weaver survived but Zwayer tragically was killed – his death would prove to be singular among all those who flew in the SR-71.

Prototype 61-7950 was written off at Edwards on January 10, 1967, during a maximum gross weight, anti-skid brake evaluation. As the aircraft left the pre-flooded test section of the runway at over 200kts, the brake 'chute failed to deploy properly. The wheel brakes locked and all six main tires blew, the brakes and tires burned out, and the wheel hubs disintegrated, causing hot shrapnel to puncture the fuel tanks, triggering a fuel fire. The pilot escaped unhurt; however, '950 was a write-off.

The 9th SRW lost its first SR-71 during a night training flight shortly after finishing refueling from the KC-135Q tanker on the night of April 13, 1967.

The pilot began climbing 61-7966 to 30,000ft in order to execute a standard push-over maneuver to hasten the aircraft through the transonic flight phase. But heavy with fuel, ’966’s airspeed fell below 0.90 Mach. To regain lost momentum, the pilot lowered the nose to level flight before again easing back on the stick. This time the aircraft shuddered into an accelerated stall, followed suddenly by a pitch-up rotation from which recovery was impossible. Both crewmen successfully ejected, but for ’966, it was the end of the line.

Pushing the envelope, losses – especially during the flight test phase of this advanced, complex aircraft – were probably inevitable. SR-71A 61-7953 was lost on December 18, 1969; both crew members safely ejected. (USAF via Tony Landis)

Six months later, on October 25, 1967, 61-7965 was lost during the descent phase of a night training flight back into Beale AFB at Mach 2.8. Unknown to the crew, the gyro-stabilized reference platform for the ANS drifted without a failure warning. This provided attitude reference signals to the primary flight instruments and autopilot. On a horizonless night, the crew were unaware that the aircraft had entered an increasing right bank. The Flight Director and the Attitude Director Indicator showed no signs of deviating from wings-level flight as the aircraft rolled over and the nose dipped into a steep dive. A quick look at the standby artificial horizon confirmed to the pilot that they were in a "screaming dive and a roll-over toward inverted flight." Despite his best efforts, the pilot was unable to recover the aircraft and the crew ejected. The subsequent accident board established that pilot error was not a factor in the loss of '965 and recommended a number of design and procedural changes, which included the addition of lights to warn of an ANS failure, relocating to a more prominent position the standby attitude indicator, and delaying night flying training to later in the syllabus.

Aircraft 61-7957, an SR-71B pilot trainer, was lost on January 11, 1968, having suffered a double generator failure near Spokane, Washington. Bad weather in the area closed possible diversion airfields, causing the crew to continue to Beale. Repeated attempts to restart the generators failed so they shut down all non-essential electrical equipment and relied on the aircraft's batteries for electrical power. During their long, straight-in approach at 175kts the natural 10-degree nose-up angle of attack caused air to be sucked into the fuel-inlet ports, interrupting fuel flow. At 3,000ft both engines flamed out and the crew successfully ejected just 7 miles short of Beale. An investigation established that the generators had failed because their power output had begun to fluctuate, causing them to drop off-line. As a result of this accident the generator trip parameters were changed, thereby ensuring that they stayed on-line in similar circumstances.

On October 10, 1968, another tire failure on take-off resulted in the loss of 61-7977, but luckily both crew members escaped serious injury. A third tire-and-wheel incident on take-off was responsible for the loss of 61-7954 at Edwards on April 11, 1969. Fortunately again, both crew members managed to escape when the aircraft came to rest. As a result of these incidents BF Goodrich considerably beefed up the tires and the issue was solved.

The fourth and final loss from the original six test aircraft occurred on December 18, 1969, when 61-7953 was on a routine test sortie. Having completed air refueling and soon after transitioning to supersonic flight, the aircraft suffered an explosion, loss of power, and severe control difficulties which forced both crew members to eject. The crew survived but ’953 smashed into the ground in Death Valley – the cause of the in-flight explosion remains a mystery.

On May 10, 1970, 61-7969 suffered a double-engine flame-out in turbulent cloud conditions over Thailand. The aircraft immediately entered a violent pitch-up maneuver, forcing both crew members to safely eject as the SR-71 crashed in the vicinity of U-Tapao Royal Thai Air Force Base. Not long after this incident an Automatic Pitch Warning system was added, which proved far superior to the original system, and no further aircraft were lost through stalls.

A freak accident befell 61-7970 and its crew on June 17, 1970, when some 20 miles east of El Paso, New Mexico. While on the air-refueling boom the aircraft suffered severe clear-air turbulence. The nose gave a small pitch down before an immediate violent pitch-up that caused the SR-71 to smash into the tail section of the tanker. The nose of ’970 was smashed from the aircraft and the pilot’s canopy caved in on him. But despite the severe damage, both crew members ejected safely and the KC-135Q managed to limp back to Beale.

“The Rapid Rabbit,” aircraft 61-7978, was written off at Kadena AB, Okinawa, after an unfortunate landing incident made in high cross-wind conditions just prior to the arrival of a tropical storm on July 20, 1972. The aircraft had its main undercarriage ripped away and broke its back after hitting a low concrete structure adjacent to the runway. Both crew members escaped unhurt when the aircraft came to a standstill.

The last SR-71 to be written off was aircraft 61-7974, during the course of an operational mission from Kadena, on April 21, 1989. The left engine completely seized while at Mach 3 and 75,000ft. Demonstrating outstanding skill, the pilot retained control of the aircraft and descended and decelerated. However, while en route to divert into Clark AFB on the Philippines, he lost all remaining hydraulic power from the right engine and the crew were

forced to eject at 15,000ft while subsonic, just off the north coast of Luzon. They were initially picked up by some fisherman before being collected from the mainland by a USAF HH-53.

OPERATIONS

Between March 1968 and October 1989, the very small “fleet” of SR-71s successfully completed over 3,500 operational missions, accruing in the process more than 11,000 operational flying hours. Each and every SR-71 operational mission was extremely demanding, requiring the highest levels of professionalism from the pilot, RSO, tanker crew members, and numerous support staff. Unfortunately, due to the limited space available within this book, we can only highlight a few of those missions, but hopefully the reader will gain an insight into the highly significant contribution made to the intelligence community by this amazing program.

Beale Air Force Base’s first SR-71 – a B model, was delivered to the 4200th SRW, on January 7, 1966, followed shortly thereafter by the second B model. It wasn’t until May 10, 1966, that the wing’s first A model arrived and thereafter a steady build-up of operational aircraft began.

On June 25, 1966, the 4200th SRW was redesignated the 9th SRW, and its subordinate squadrons became the 1st and 99th SRS – the 99th SRS was deactivated as an SR-71 unit in March 1971, after which its assets were transferred over to the 1st SRS.

The tail art seen here was probably inspired by the 1968 thriller Rosemary's Baby, about a mother who unwittingly gave birth to the spawn of Satan, in this case also morphed with a SAM! One of the posters for the movie shows a similar winged, horned, and tailed red baby. It was seen while 61-7980 was deployed to Det 1, at Kadena on September 18, 1969.

On March 8, 1968, Operation Glowing Heat began (this codename was used whenever SR-71s were deployed from Beale). Over the next five days aircraft '978, '976, and '974 were ferried from Beale AFB to Kadena AB, Okinawa, to take over reconnaissance missions previously flown by the CIA's A-12 Oxcart program. The unit would eventually be christened Detachment 1 of the 9th SRW – or Det 1. It was while at Okinawa that the SR-71 received its nickname, "Habu," after a dark, poisonous pit viper, indigenous to the Ryukyu island chain. Although "Blackbird" has long been

the name publicly associated with the SR-71, it's a title that was shunned by crew members.

Majors Jerry O'Malley and Ed Payne successfully completed the first ever SR-71 operational mission in aircraft '976 on March 21, 1968. Their route followed that of the first Blackshield A-12 sortie, flown ten months earlier.

The post-mission reconnaissance "take" was stunning. The aircraft's High Resolution Radar (HRR) revealed the location of heavy artillery emplacements around the besieged outpost of Khe Sanh, and a huge truck park used in support of the guns, both sites having managed to elude previous US recce sorties. Over the next few days air strikes were mounted against both targets, reducing their effectiveness dramatically. After a 77-day siege, Khe Sanh was at last relieved on April 7, 1968 (two weeks after '976's "discovery" sortie). As a result of their significant contribution to this highly successful mission, O'Malley and Payne were each awarded the Distinguished Flying Cross. On its very first operational sortie, the SR-71 had proven its value and it would continue to do so not just during the Vietnam War, but on many hundreds of other occasions over the coming years.

By late summer 1968 the three SR-71s serving at Kadena had each accumulated 300 flight hours, and it was therefore time for them to be returned to the United States to undergo essential maintenance. Consequently, over a seven-day period in September, Glowing Heat saw '980, '970, and '962 positioned to the detachment from Beale, and '976, '974, and '978 return home. Crew rotations were also an important part of the detachment's operating routine, and by the end of 1968, no fewer than 21 crews had flown the SR-71 into battle. As the aircraft's reliability increased and maintenance facilities at Kadena improved, the time that aircraft were able to spend in theater increased, thereby reducing the frequency of the swap-out operation.

YOM KIPPUR

On October 6, 1973, a meticulously planned attack backed by the Soviet Union was launched by Syria to the north and Egypt to the west against Israel. The blitzkrieg-style attacks completely caught Western intelligence agencies off-guard. To plug the reconnaissance void, 9th SRW Commander, Colonel Pat Halloran, was ordered to prepare a series of long-distance SR-71 missions launched from the US eastern seaboard that would overfly the warring factions and recover into RAF Mildenhall, England. However, in a futile move calculated to ingratiate Arab approval and thereby secure the continued supply of Middle East oil, the UK's Conservative government denied its long-term ally operating authority from the UK base. Consequently, the missions were amended and would be flown non-stop to the United States and back!

Two SR-71s, '979 and '964, were positioned to Griffiss AFB, NY, and at 0200hrs on October 13, Majors Shelton and Coleman got airborne in '979 and shortly afterwards completed the first air refueling hook-up in what was to be the SR-71's longest operational mission to date. Recovering back into Griffiss 10 hours 18 minutes later (6 hours 8 minutes of which was at Mach 3), the non-stop mission over the Middle East and back was supported by no fewer than 14 KC-135Q tankers – two from Griffiss, four from Goose bay in Canada, and eight out of Torrejon AB, Spain.

The high-quality reconnaissance "take" provided intelligence analysts with much-needed information concerning the disposition of Arab forces in the region, which was made available to the Israelis. In addition, Congress granted President Richard Nixon his request for $2.2 billion in emergency aid for the Israelis and the US began a huge airlift of war materials. This action incensed key Arab members of the Organisation of Petroleum Exporting Countries (OPEC), who imposed a complete embargo on oil exports to the US together with a unilateral 70 percent increase in oil prices and a 5 percent per month cut in production. The decision caused widespread panic in Western Europe, which depended on the Arab states for 80 percent of its oil.

SR-71A 61-7968, Article 2019, refuels from KC-135Q 80074. Tanker support was crucial to virtually all SR-71 operational missions. (Lockheed Martin)

By October 14, however, the situation on the Syrian front was swinging in favor of the Israelis. But in the Sinai desert the Egyptians launched a 100,000-strong offensive toward the east, and the result of this attack developed into one of the biggest tank battles in history. The Israeli forces gained ground and also established a bridgehead west of the Suez Canal that threatened to cut off the Egyptian army. With the Egyptian military situation becoming increasingly precarious, President Nixon announced that US forces across the globe had been placed on military alert following receipt of information indicating that the Soviet Union was planning “to send a very

substantial force to the Middle East to relieve the beleaguered Egyptian Third Army, now completely encircled in the Sinai."

This tense period in superpower relations was somewhat defused when Soviet Secretary Brezhnev supported a United Nations motion on October 24 that would eventually end the Yom Kippur War. Meanwhile, however, SR-71 surveillance missions continued to monitor the situation.

Between October 13, 1973 and April 6, 1974 all nine of these long-distance missions launched from the US were successfully completed without a single ground or air abort (the final two sorties were flown from Seymour Johnson AFB South Carolina, after the detachment moved south to escape the harsh New York winter). They represented the pinnacle of operational professionalism as well as being testament to the long reach of the aircraft and its ability to operate with impunity in a sophisticated, high-threat environment.

DETACHMENT 4

Having visited the Farnborough Air Fete in the UK in September 1974 (establishing in the process two world speed records, see Appendix 4), the same SR-71 aircraft, '972, flew into RAF Mildenhall on April 20, 1976. Two missions were flown in an attempt to gather HRR imagery of the important Soviet submarine bases located in the Barents Sea – home of their Northern Fleet. But off the west coast of Norway the aircraft encountered unseasonably high outside air temperatures, resulting in a disproportionately high fuel burn. The Habu would barely be able to reach its tankers, so the crew prudently aborted the mission and returned to Mildenhall. Although the sortie failed to complete the reconnaissance gathering phase of the mission, it did obtain extremely useful information that helped shape the aircraft's flight profile during future deployments to Northern Europe.

On September 6, 1976, 61-7962 deployed to RAF Mildenhall. Six sorties were flown and HRR imagery, Photint, and Elint were collected of

Soviet/Warsaw Pact positions in East Germany, as well as the Soviet sub pens as attempted by ’972 earlier in the year. The aircraft returned to Beale, after a highly successful European tour that lasted 19 days.

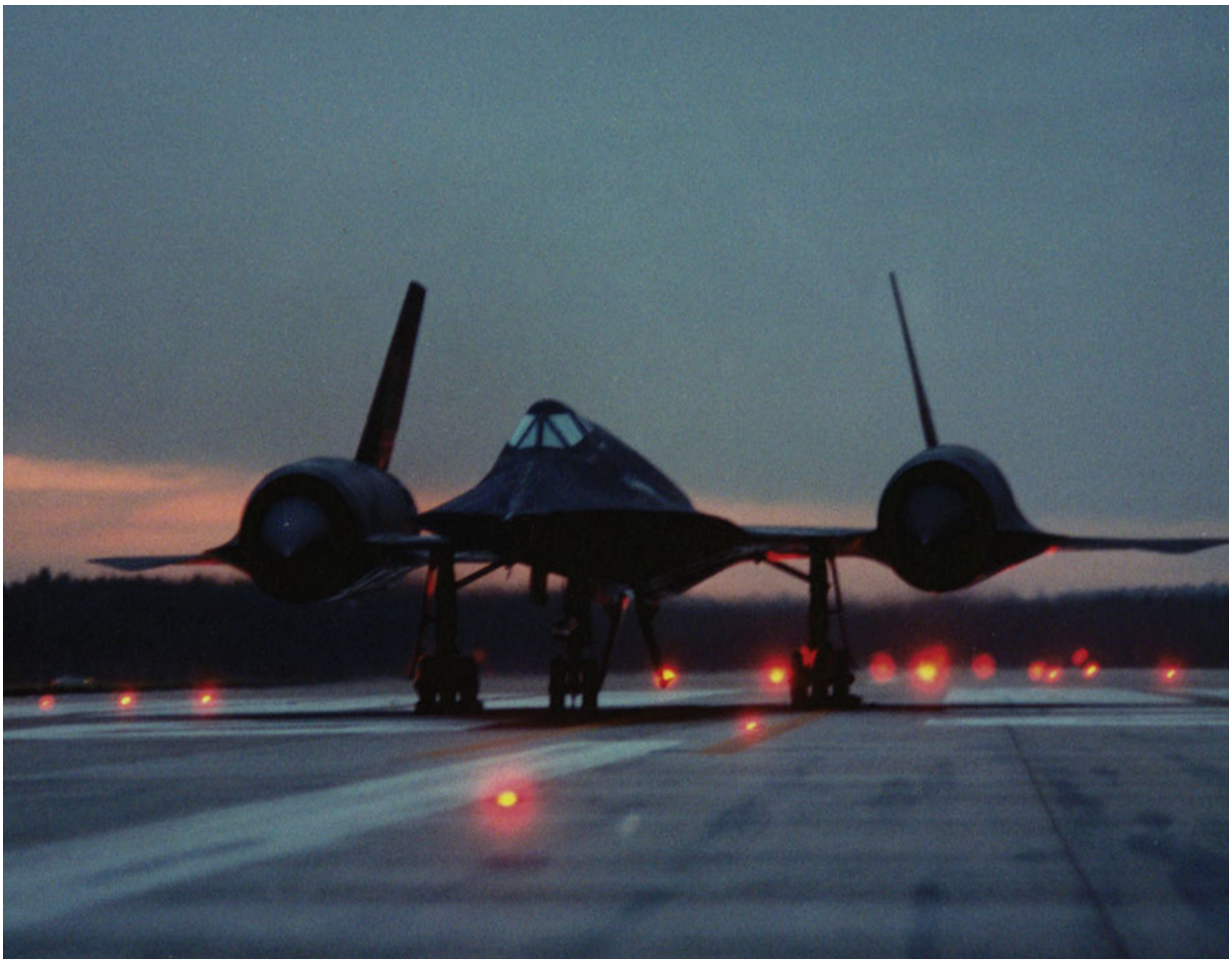
Over the next few years the number and length of SR-71 deployments to Mildenhall continued to grow. Such was the proven success of the SR-71 in the European Theater of Operations that on March 31, 1979, Detachment 4 of the 9th SRW was established – at this time, however, it was a joint unit operating both the SR-71 and TR-1. However, these arrangements changed on April 5, 1984, when Prime Minister Thatcher announced that a permanent detachment of SR-71 aircraft had been formed at RAF Mildenhall.

The resurgence of Islamic fundamentalism in the Middle East in the early 1980s and the general destabilizing effect that this had throughout the region guaranteed that the SR-71 would be kept busy monitoring many of these “hotspots.” Missions over the Lebanon were flown by Det 4 crews to keep tabs on the Syrian and Israeli armies, as well as on various contraband movements which supplied Islamic jihad warriors and other supporting groups. However, after confrontations in the Gulf of Sidra, and various terrorist activities, it was Libya that proved to be the next major flashpoint.

Following meticulous planning, Operation El Dorado Canyon was a combined strike by US Navy and USAF assets against specific Libyan military targets identified around Tripoli and Benghazi. The attack was launched during the small hours of April 15, 1986. The acquisition of aerial reconnaissance photographs to enable photo interpreters to complete bomb damage assessment reports was an essential task demanded by the Supreme Commander himself – President Reagan. However, with the sophisticated, integrated Libyan air defense system on full alert immediately after the raid, it was the SR-71 that possessed the necessary performance and systems capability that could survive in such a high-risk environment and acquire the quality imagery demanded by the photo interpreters.

On consecutive days, a total of three missions were flown by Det 4 crews over the strike areas. The French, as usual, refused overflight access into the Mediterranean, necessitating a laborious flight around the Iberian Peninsula and entry via the Straits of Gibraltar, adding significantly to the flight time. The importance of these SR-71 missions required the use of an airborne

spare, to cover possible mechanical malfunctions in the primary aircraft. The first of these high-profile sorties was completed in 61-7980. Unfortunately, cloud cover over Tripoli prevented any useful imagery from this area being collected by the aircraft's cameras. Use of the SR-71's HRR would have easily solved this problem; however, senior officials at the Pentagon wanted to release imagery to the world's media to prove that the attacks were proportionate, selective, and accurate, and the highly classified nature of the SR-71's HRR capabilities prevented this. Consequently, a second mission was completed in 61-7960, but the aircraft suffered a sensor failure; therefore a third sortie was flown on April 17, again in aircraft '980. This series of sorties proved unparalleled in over 20 years of SR-71 operations: with just two aircraft, supported by a maintenance team that was staffed to support only two to three sorties a week, six missions had been flown in three days!



Detachment 4 of the 9th SRW was formed at RAF Mildenhall, England, on April 5, 1984, following a number of earlier SR-71 Temporary Duty deployments. Having completed EGT checks, 61-7964 lines up and holds on runway 29 in readiness for a pre-dawn departure. (Paul F. Crickmore)

NORTH KOREA

In addition to supporting in-theater operations during the Vietnam War, Det 1 were also tasked to provide the Commander, United States Forces, Korea; Commander in Chief, Pacific Fleet (CINCPACFLT), and the Intelligence Center Pacific, with advanced warnings of North Korean intentions by examining "indications and warning targets." Given that by 1977 North Korea had a standing army of 450,000 (making it the fifth largest in the world), and the unpredictability of the country's belligerent dictator – Kim Il Sung, who was committed to the reunification of the peninsula under his form of autocratic communism – it is perhaps not surprising that after the Vietnam War, these monitoring missions became an important role for Det 1.

As is apparent, all SR-71 missions were highly regulated, but that didn't stop North Korea from voicing their disapproval of such flights. Matters came to a head on August 26, 1981, when '976 was fired upon by a North Korea SA-2 during the second, west-to-east pass over the DMZ. The pilot Major Maury Rosenberg saw the missile contrail and accelerated to Mach 3.2, while making a slight turn away from the SAM, which exploded a good 2 miles behind the Habu (see cover image).

This extremely serious incident caused tensions on the peninsula to rise significantly. President Reagan roundly denounced "this act of lawlessness" – as usual, North Korea denied the missile-firing charge, despite irrefutable photographic evidence to the contrary.

To help defuse the volatile situation, SR-71 reconnaissance flights to the area were suspended for six days, after which the reconnaissance line was moved

even further to the south. On September 26, Deputy Secretary of Defense Frank Carlucci visited Det 1, and explained that the DMZ route package had been moved further south only temporarily, and that the former routes would be reinstated after “certain preparations” were made – he didn’t elaborate any further.

The “Big Tail” modification completed on SR-71A 61-7959, Article 2010, consisted of an 8ft 10in extension in order to create extra capacity for additional sensors and ECM systems. It was, however, never deployed operationally. (Lockheed Martin)

Lt Cols Tom McCleary and his RSO Stan Gudmondson departed RAF Mildenhall for the last time in SR-71A 61-7964, Article 2015 on January 18, 1990. Despite the Senior Crown program having been terminated two months earlier, and to catch the Soviets off-guard, the crew completed an operational mission into the Barents Sea on their return trip back to Beale. (Paul F. Crickmore)

On October 3, Lt Gen Mathis (Assistant Vice Chief of Staff) held a special briefing for Det 1's crew members during which he outlined four special category missions which were to be flown on routes that replicated those flown during the August 26 shoot-down attempt. He emphasized that timings would be especially critical, and when questioned why by one of the pilots, the general explained that "Wild Weasel" anti-radar strike aircraft would be poised to hit any North Korean SAM site within 60 seconds of a

launch against the SR-71. The tight time constraints would ensure that the strike aircraft were headed in the right direction at the moment a missile was launched. President Reagan had personally approved the plan.

On October 26, 1981, following extensive mission planning and detailed briefings, ’975, flown by Majors B. C. Thomas and his RSO Jay Reid departed Kadena on the first of those four special missions. The mission was executed exactly as planned and happily, for whatever reason, the North Koreans chose not to launch a missile at this or any other “trawling mission,” and all four sorties recovered safely after each four-hour flight.

Monitoring North Korea continued to be a key mission for Det 1’s SR-71s. Indeed the final operational sortie flown from Kadena before “Senior Crown” was deactivated was a 3.4-hour flight, flown in the vicinity by SR-71 ’962 on September 25, 1989, by Majors Don Watkins and his RSO Bob Fowlkes.

PROGRAM TERMINATION

Two operating issues plagued the Senior Crown program for most of its life, namely its high operating costs in comparison to other fixed-wing assets and provision to fund those costs. Initially the cost versus benefit argument was easy to justify (particularly during the Vietnam War), on the basis that the detailed, broad synoptic coverage secured by the platform was essential for both national and theater commanders and that the acquisition of such material was beyond the capability of other aircraft – especially in high-threat environments.

Initially Department of Defense funding for Senior Crown was provisioned from within the so-called “black world” budget. This protected funds for highly classified programs from scrutiny and also stabilized funding levels from cyclical budgetary raids that were the bane of “white world” programs. However, in 1975, SR-71 funding was moved into the white world. From there on Senior Crown had to compete for its funding against all other

Department of Defense programs. The SR-71's Program Element Monitor (PEM) at the Pentagon faced major problems when it came to drumming-up support, firstly because the classified nature of the program meant that it was designated "Top Secret/Sensitive Compartmented Information, Special Access Required," which meant that only those with specific clearances and a need-to-know were privy to the intelligence it generated. Naturally, this considerably restricted the number of senior officers and officials that the PEM could talk to. The second issue was that Senior Crown fell under the command of SAC, whose primary responsibility was to secure funding for two of the three legs of the nuclear triad – nuclear intercontinental ballistic missiles and its force of nuclear equipped B-52 bombers. This was irksome because Senior Crown generated intelligence for not just the USAF, but also other government agencies, including the US Navy and US Army, but SAC were saddled with the program's entire operating costs.

When program advocate, ex SR-71 pilot (later to become 9th SRW Commander, and ultimately Commander of Tactical Air Command) General Jerry O'Malley was tragically killed in a freak accident on April 20, 1985, the USAF lost a top leader tipped to become the Air Force's next Chief of Staff. Senior Crown also lost one of its most powerful supporters. The SR-71 didn't feature in the non-O'Malley Air Force. The platform was "living on borrowed time" without investment for an electro-optical (digital) system for its cameras and a data link that would enable its Advanced Synthetic Aperture Radar System (ASARS) to generate real-time/near real-time transmission of its reconnaissance data. By 1988 program detractors occupied senior positions in both the USAF and SAC and it looked as though Senior Crown was about to be axed. However, Admiral Lee Baggot, Commander in Chief Atlantic (CINCLANT), insisted that no other platforms (including satellites), were capable of gathering the vital intelligence he required regarding the Soviet subs based on the Kola peninsula, and he took his battle right to the Joint Chiefs of Staff, and funding was secured for a further year. But as the end of that fiscal year approached, the future of the program looked increasingly bleak. On October 1, 1989, all SR-71 operations were suspended with the exception of a minimum number of proficiency flights. Finally, on November 22, despite the misgivings of 40 members of Congress, including chairman of the Senate Committee on Armed Services, Senator Sam Nunn, Senior Crown was terminated. Two months later, on January 26, 1990, the SR-71 was officially decommissioned

in a ceremony at Beale AFB. The program's detractors had finally won the day.

In compliance with the decommission decision, three SR-71s were placed in storage at Air Force Site 2, Palmdale. But virtually all other remaining aircraft – including the surviving A-12s – were cut-up, transported, and then reconstructed as exhibits, at various museums around the United States, with the exception of three SR-71s being utilized by NASA at Edwards AFB (see Museum Exhibits chapter). However, following an unprecedented Congressionally Directed Action, funding was provisioned for one year, for a limited SR-71 reactivation program which was implemented on January 5, 1995. Of the three platforms placed in deep storage at Palmdale, only 61-7967 was called to arms by the Air Force. The other A model to be recommissioned was 61-7971, which was one of the three aircraft to have been loaned to NASA. Three months after the reactivation date, '971 had undertaken all the necessary equipment installs and, following a second FCF, was signed off mission-ready. In contrast, it took seven FCFs to wring out all the glitches in '967, which wasn't declared ready to join the line until January 12, 1996. Co-located with NASA to keep operating costs to a minimum at Edwards AFB, Det 2 of the 9th Reconnaissance Wing was a thorn in the side of Air Force officials that had terminated Senior Crown six years earlier. As a result, during its brief existence, Det 2 was continually embroiled in political shenanigans. On October 14, 1997, President Bill Clinton line-item vetoed the program; with immediate effect all Air Force Blackbird flying ceased, this time permanently.

SR-71A 61-7980 is seen here as the Senior Crown program was terminated, wearing the Det 4 emblem chalked on its tail. Later re-christened 844 by NASA, the aircraft saw valuable service as the platform carrying the Linear Aerospike SR-71 Experiment (LASRE). (Lockheed Martin)

During the time of its reactivation the SR-71s of Det 2 had flown a total of 150 training sorties during 365.7 flight hours. The final Det 2, SR-71 sortie was flown on October 10, 1997, in aircraft ’967 on training route Brandy, which lasted 4.1 hours.

FLYING THE SR-71

In less than 20 seconds 60 tons of titanium and fuel reached 180kts (VR, rotation speed). Standard operating procedure called for take-off to be made with either a 50 or 66 percent fuel load. This ensured that when the tanks (filled from a waiting KC-135Q tanker shortly after getting airborne) were purged of air, as gaseous nitrogen (LN2) replaced the burned-off fuel thereby insuring against inadvertent vapor ignition, triggered by the hot ‘wet’ fuel tanks encountered at high Mach cruise. In addition a relatively light fuel load ensured that tire rotation limits were adhered to and that the aircraft maintained a greater degree of control in the event of an engine failure on take-off. (Paul F Crickmore)

In August 1974, Colonel Rich Graham joined the Senior Crown program as a pilot. He progressed to become an instructor before being promoted to Chief of the Standardization/Evaluation Division, in 1978. Two years later he was appointed 1st Strategic Reconnaissance Squadron Commander, then, following a four-year tour of duty at the Pentagon, he returned to Beale AFB to become the 9th Strategic Reconnaissance Wing Commander. Having accumulated over 760 hours flying the SR-71, there are few better qualified to talk through what it was like to fly the SR-71 on an operational mission:

The start of every SR-71 reconnaissance mission began the day prior to the sortie. The pilot and RSO met at the Operations building, to study and mission plan for their specific sortie. Don Emmons was the RSO I flew with for over seven years. We never mixed and matched crews for operational sorties; you flew with the same RSO all the time. If one of you were sick and unable to fly, the other crew member was, for all practical purposes, grounded as well. A backup crew was always designated to be ready to take the primary crew's place in the event that they were unable to pass the preflight physical.

Our method of mission planning was to go through the entire route of flight doing "what if" drills. For example, "what if we are low on fuel here, what if we see MiGs here, what if we lose oil pressure here, etc." Crews had to have a general plan of action along their entire route of flight, because flying at

over 2,000mph you didn't have time in-flight to discuss or justify your actions. There's an old saying among the SR-71 crews, "You've never been lost until you've been lost at Mach 3+." A wrong action could put you on the front page of national newspapers! Typical mission planning lasted about 2–3 hours depending on your experience and familiarity with the sortie. Both the primary and backup crew planned for each sortie, in case one of the primary crew members were sick the next day. After mission planning you were free to do whatever you liked as long as you got a minimum of eight hours' sleep before wake up time.

While we were sleeping an enormous amount of effort was taking place throughout the night to prepare the SR-71. The crew chief was making the plane ready for flight with the correct fuel load and oil added to the engines. Liquid nitrogen had to be re-serviced to provide gaseous nitrogen to inert the volatile fuel tanks. The J-58 engine's unique chemical ignition system, utilizing TEB, had to be carefully added to their tanks. All the cameras and sensors were loaded on the plane and then checked for proper operation. The preprogrammed celestial navigation system, called the Astro-Navigation System, had to be lowered into the aircraft and checked for accuracy. Many people of different disciplines had to get the aircraft ready for flight. The crew chief of the plane was in charge of orchestrating all these tasks, and at the same time preparing his plane for a safe flight.

Waking up early the next day, our first order of business was to drive to a location on base that provided both the primary and backup crew with a steak and eggs meal. We were required to eat the "high protein/low residue" meal prior to every flight in the SR-71 to ensure we were properly nourished. While eating it was also a good opportunity to discuss any last-minute details of the flight with the backup crew. After about 30 minutes of "gourmet" dining we drove to Det operations for the mission briefing.

Major Rich Judson (left) and his RSO Lt Col Frank Kelly relax on recliners as they are driven out to their waiting SR-71 in the PSD “bread” van. (Paul F. Crickmore)

Once lined up on the runway, ground technicians positioned wooden wedges in front of each of the mains to enable the pilot to undertake EGT trim checks. These were then removed prior to take-off via the use of sledgehammers. (Kevin Gothard)

We next reported to Operations and gathered up our classified checklist, maps, flight plans, and other mission materials that were stored in a safe. These large five-drawer safes gave each crew member a drawer within which to store their own classified materials; each had its own combination lock. On top of that, all of the five-drawer safes had a steel bar blocking the individual's drawers from opening as well. Protecting our classified information was something we took very seriously! In the mission briefing room was the Det Commander, intelligence personnel, the primary and backup crews, the maintenance officer and crew chief for the plane, mission

planners, weather personnel, and the KC-135Q tanker honcho. The purpose of this briefing was to ensure that everyone in the room was "singing from the same sheet of music" once the mission briefing was over and everyone departed. This would be the last chance to ask any pertinent questions about the mission.

Around 1977 the National Security Agency gave a briefing to the Det 1 Commander and crews about how the Soviets were using fishing trawlers around Okinawa to listen to all our radio transmissions and passing along the information to other Soviet allies. Their recommendation to the Det Commander was to develop radio silent procedures. Once the SR-71 is above 60,000ft there was no longer a need to communicate with anyone, since we owned all that airspace anywhere on the globe. Over a period of about a year we finally developed radio silent procedures that allowed us to taxi, take off, accomplish multiple air refuelings, flying halfway around the globe and never talk to anyone over the radio. The only occasions that we were allowed to break radio silence was in the interest of safety or to get the mission accomplished.

The mission briefing lasted about 20 minutes, and after it was over the crews had a few minutes to relax or ask questions. The backup crew drove out to the aircraft to preflight both cockpits and placed all the switches ready for the "Before Engine Start" checklist. They talked to the crew chief, flagging any discrepancies they might have found with the plane and he did likewise with them. They then stayed around the hangar until the primary crew came out.

Don and I would then head to the Physiological Support Division (PSD) room to suit up. Each crew member had to have a brief physical examination prior to every flight in the SR-71. It consisted of checking and recording blood pressure, pulse, temperature, weight, and making sure there were no sinus problems. If you passed the physical the next step was getting into the pressure suit.

Depending on how experienced you were – and how experienced the PSD technicians were – it would take about ten minutes to get into the suit. After donning the suit we sat down in large, leather, reclining chairs where PSD technicians made last-minute checks and completed final preparations – this

included fully inflating the pressure suit to check for unacceptable leakage. Once the pressure suits checked out satisfactorily we'd walk to the PSD van that would take us out to the hangar and the waiting plane. The backup crew would be there to greet Don and I in the van and report that the aircraft was Code 1, meaning no discrepancies were found.

PSD technicians would position themselves both sides of each cockpit and accomplish a preflight check of each cockpit. Once they signaled with a "thumbs up" Don and I would walk out of the van and up the stairs to the waiting cockpits. Early in the morning of September 7, 1976, Don and I climbed eagerly into each cockpit of aircraft tail number '962 at RAF Mildenhall, in England. Now it was up to PSD to connect our two oxygen hoses, the communications cord, face heat cord, the two parachute fittings, the lap belt, and our survival kit (that you sit on) attached to the pressure suit. All of these connections were mandatory for our survival in case of an ejection. Our lives were literally in their hands by making all the right connections and mating us to the ejection seat – with the pressure suit on, it's impossible for the crews to visually see all the connections.

Once PSD completed their checklist Don and I checked in with each other over the interphone system and were ready. During early SR-71 operations out of RAF Mildenhall, a starting cart called the "Buick" was used start the massive Pratt & Whitney J-58 engines. It was wheeled underneath each engine and utilized a direct mechanical drive shaft, connected to the engine gear-box. Each starting cart had two Buick V-8 engines mounted inside. With reduction gears from both engines the Buick provided sufficient torque to rotate the engines for start.

Once the engines were started we completed several ground checks with the crew chief to make sure all systems were working satisfactorily. Everything was good so far. I had never heard British Air Traffic Controllers before. Their reassuring voices and strange accents boosted my confidence for my first flight in Europe. As I added power and started to taxi, the backup crew, driving a military car with UHF/VHF radios preceded the SR-71 aircraft. Their primary purpose in leading the SR-71 out to the runway is to look for any foreign objects on the taxiways, like a nut or bolt that could easily cut the 400 PSI pressure tires. Following the SR-71 were several maintenance

vans with key personnel onboard just in case we needed advice if any discrepancies were discovered during the engine run up.

At the end of the taxiway the tires were chocked and I ran each engine individually up to 100 percent power and held the brakes tightly for 30 seconds while onboard systems recorded various maintenance parameters to be used after the flight. If we found any problems in the cockpits during the run up, the crew chief could plug into our intercom system and discuss the problem with us. The SR-71 had something unique that I had never seen in any other plane. We were able to actually adjust the Exhaust Gas Temperature (EGT) of each engine with our EGT trim switches. Normally, the switches were left in the automatic setting, but if needed, I was able to increase or decrease the EGT of each engine by moving the trim switches. When the EGT trim switch was held in the increase position, a small electric motor on the engine fuel control increased the ratio of main afterburner fuel flow to main afterburner combustion pressure and thus increased the turbine discharge temperature (EGT). During the engine run up we had to ensure the EGT was within a proper temperature range depending on the outside air temperature.

Once the engine runs were completed the chocks were removed and all the maintenance folks got back inside their vans. About one minute before the prescribed takeoff time I made a radio call to the Mildenhall tower and we were “cleared on the runway for takeoff.” The mobile crew immediately drove onto the runway before us to check for anything that might be on the runway. I lined up the plane straight down the runway centerline, completed a few checklist items with Don, and we were ready to go. Don has a clock in his cockpit that is accurate to one-hundredth of a second. Our technique was for him to give me a 5-second count down prior to the takeoff time. As Don said “three” I slowly brought both throttles up to full military power and when he said “hack” I released the brakes at full military power. I quickly scanned the engine parameters and then lifted the throttles upward and forward into full afterburner… 68,000 pounds of thrust. Very seldom do both afterburners light off at the same time, giving the aircraft a very pronounced “kick” in each direction as you begin the takeoff roll. Once in full afterburner the acceleration is fast! Another quick scan of the engine instruments in full afterburner to make sure everything is okay as I raced down the runway.

Once the SR-71 pilot had stabilized the aircraft in the pre-contact position, the tanker's boom operator fine-tuned the process, flying the boom the final few feet before extending it hydraulically into the receiver's refueling receptacle. Once on the boom, the tanker's co-pilot activated the booster pumps that sent JP-7 into the hungry Habu's fuel tanks. (Lt Col Blair Bozek)

Looking for a speed of around 160 knots at the 3,000 foot runway marker I quickly determined that the acceleration was going as expected. Steering straight down the runway with the nose wheel steering, I slowly began bringing the control stick back to rotate the nose off the runway at 180 knots and broke ground at 210 knots. Gear up and accelerate to 400 knots and hold that for the climb out until reaching 0.9 Mach. Level off around 25,000ft we started heading north. Depending on fuel load, it took around 2 minutes to

reach 25,000 feet. We were prohibited from flying supersonic over the landmass of the UK. Don had the navigation system programmed on a direct course to our awaiting KC-135Q tankers. We were to join up with the three tankers over a common rendezvous point call the Air Refueling Control Point (ARCP).

Our three tankers had taken off from Mildenhall well before us and were flying a loose formation in the air refueling orbit off the west coast of Norway 30 minutes prior to our arrival. The SR-71 had a semi-secure means of receiving the distance and bearing to the waiting tankers. Likewise, they had the same equipment onboard and knew our distance and bearing from them. The lead tanker navigator had been flying the race track pattern well before our arrival and knew the precise wind drift over the ARCP. At the precise distance from each other, the tanker navigator told the aircraft commander when to make his final turn. As I continued to fly to the ARCP at 0.9 Mach the distance between us was closing fast, but once the tankers started their turn and rolled out, we ended up 3 NM [nautical miles] in trail with them. The tankers were flying at 325 knots and I closed in slowly on the lead tanker to be in a pre-contact position behind the refueling boom. Don and I accomplished the pre-refueling checklist as we slowly moved closer to the tanker.

I stabilized the plane with the refueling boom right in front of my eyes, about 20 feet away from my front windshield. The boom operator then flew the boom into the SR-71's air refueling receptacle. Once contact was made, hydraulic jaws held the boom locked into position. It took us around 15 minutes to get to full tanks… 80,000 pounds of JP-7. Once the boom was mated to the plane we could talk to the tanker crew via a boom inter-phone system. The first thing we heard over the inter-phone was, "You're taking gas." Those were always my favorite words!

Don now controlled the fueling of the six main tanks. The goal was to be at the End Air Refueling (EAR) point with precisely 80,000 pounds of fuel onboard and a pressure disconnect. Making all three of those requirements happen all at the same time is an art for the RSO. Don was a master at it! As you know, when pumping gas into your car's tank at the maximum rate, the back pressure often stops the refueling early and you can usually get more fuel in the car if you pump it slowly. The same applies to the SR-71.

Transferring fuel into the SR-71 at 6,000 pounds per minute is fast, and once 70psi back pressure is sensed, the air refueling boom automatically disconnects. That's what you want to happen at the EAR point, not prior to reaching it. Don had the tankers pump gas with all four of their pumps on to start with, but as we approached the EAR he told them to take it down to three pumps, then down to two pumps. Within miles of the EAR he had them drop to one pump only. He was an expert at controlling the tanker's pumps so that we arrived at the EAR point with full tanks and a pressure disconnect. I slowly backed away from the tanker and cleared him on the right side. As they turned to the left Don and I completed the post air refueling checklist.

We were now ready to start the climb to 71,000 feet and acceleration to Mach 3.0. Any aircraft that goes through the sound barrier creates a tremendous amount of drag in the transonic speed region. For the SR-71, speeds of between 0.95 and 1.05 Mach had the highest drag on the aircraft and, consequently, higher fuel consumption. Our goal was to accelerate through that high drag regime as fast as we could and we accomplished it with a maneuver we called the "Dipsy Doodle" [the same manoeuver was carried out by A-12 pilots, but referred to as the "Whifferdill"]. I went to minimum afterburner and held a constant 0.9 Mach climb. Upon reaching 30,000 feet I advanced the throttle to full afterburner and let the plane climb to 33,000 feet where I slowly accelerated to 0.95 Mach and began a gradual transition to a descent. Once through Mach 1.05 in the descent I began to slowly raise the nose of the plane to achieve a constant 450 Knot Equivalent Air Speed (KEAS) climb schedule in full afterburner.

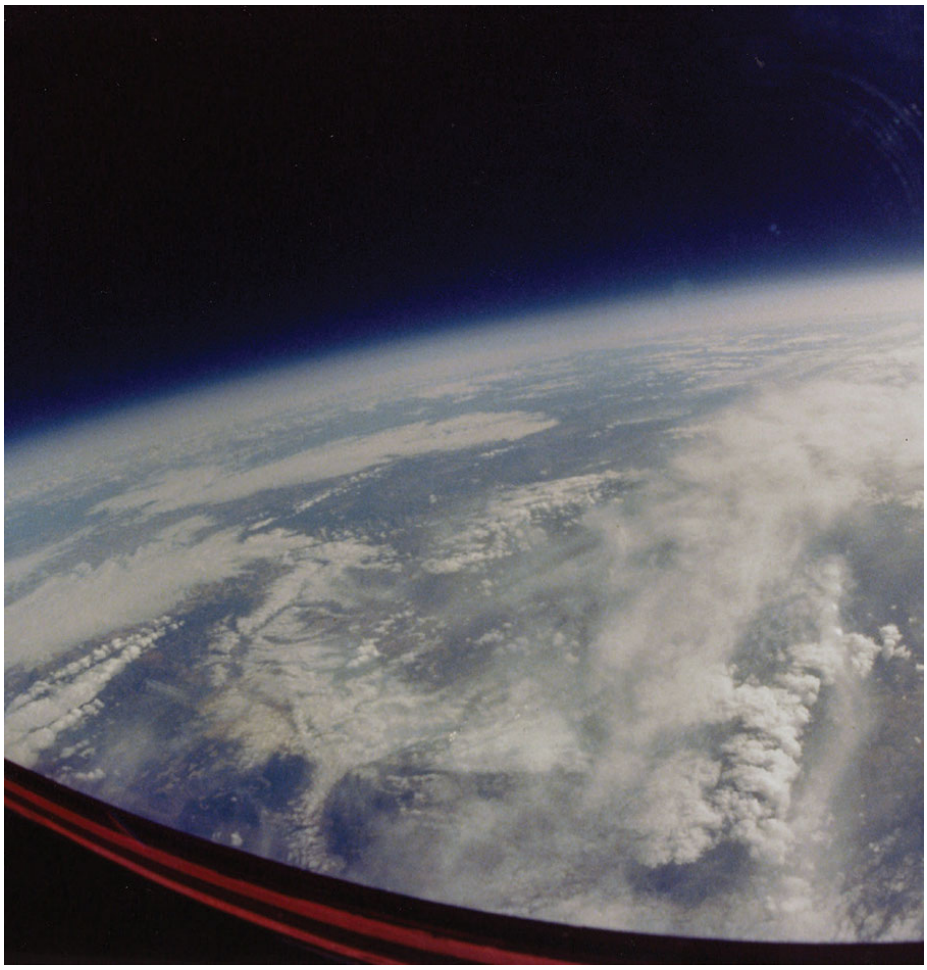
After I trimmed up '962 to hold 450 KEAS, I engaged the KEAS Hold function of the autopilot. At a constant KEAS climb the Mach number increases as you climb. Now the autopilot held the airspeed constant while I devoted my attention to other parameters in the cockpit during the climb and acceleration. As I passed through Mach 1.6 I made sure both spikes unlocked and were starting to move aft into the inlet. For each tenth of Mach increase above 1.6 the spikes move aft 1⅝ in for a total aft movement of 26in into the inlet. Forward bypass doors, surrounding the inlets, begin to modulate individually to bypass excess air to engine requirements, overboard. These doors create extra drag on the SR-71. At around Mach 1.7 to 2.3 the Inlet Guide Vanes (IGVs) shift from an axial to cambered position.

Once the IGVs shift I place the aft bypass in the “B” position, for the respective engine. This action allows the forward bypass doors to close down slightly, eliminating excess drag on the plane.

The goal for me is to keep the forward bypass doors modulating around 5 to 10 percent open. Any more open than that and the excess drag will hurt fuel consumption to the point where I may have to abort the mission. However, if either one of the forward bypass doors go fully closed it will create what is called an “unstart.”

At Mach 2.6 the KEAS bleed schedule begins decreasing the 450 KEAS we were holding. The schedule decreases the KEAS 10 knots for each tenth of Mach acceleration. For example, at 2.7 Mach the airspeed is 440 KEAS, at 2.8 Mach 430 KEAS, 2.9 Mach 420 KEAS, and at Mach 3.0 410 KEAS. With standard day temperatures outside you should be leveling off around 71,000 feet, Mach 3.0 and 410 KEAS.

However, when Don and I passed through 45,000 feet it was obvious we were climbing and accelerating extremely fast! We needed the outside air temperature to remain cold for completing the mission but this was bizarre. With the autopilot engaged the control stick becomes disabled and you fly the SR-71 in pitch and roll by slowly rotating two serrated wheels on the right console. One wheel for the pitch axis and the other for the roll axis. Reaching our normal level-off altitude of 71,000 feet I slowly lowered the nose of the Blackbird by rotating the small pitch wheel on the autopilot forward, simultaneously reducing the throttles to minimum afterburner to hold Mach 3.0. By now we were well past the Arctic Circle, leveling off just beyond Bodo, Norway.



Cockpit workload within the SR-71 was always high and demanding. However, during occasional brief periods that permitted a quick glance outside, the view from 80,000ft plus was always breathtaking. (Lt Col B. C. Thomas)

As we approached the “sensitive area” at the most northern tip of Norway we went through our last-minute checks. We defined the sensitive area as that airspace where anything could be expected from a foreign country in terms of hostile acts. As we made the turn more easterly into the Barents Sea the Mach began accelerating and I was already at minimum afterburner. Unlike the Concord flying at Mach 2.0, coming out of afterburner is not an option for Mach 3.0 flying. I slowly rotated the pitch wheel aft and climbed, hoping to reach an altitude that would sustain Mach 3.0 without accelerating

further. By now I was at 74,000 feet at Mach 3.2 and still climbing. We were definitely in colder temperatures now!

During a reconnaissance mission into the Barents Sea “collection area” on October 6, 1986, aircraft 61-7980 was crewed by Major Ed Yeilding and his RSO Curt Osterheld. While in a left banked turn, Ed spotted an aircraft some miles off that subsequently turned out to be a MiG-31 “Foxhound” flown by Major Mikhail Myagkiy of the 174th GvIAP, sent up on a practice interception against them.

The plane continued to accelerate every time I tried to level off at a higher altitude. I was now up around 77,000 feet. I asked Don about our ground speed. He replied, “We’ve got around 100 knots of tailwind.” Typically,

anywhere in the world, the winds above 70,000 feet are never more than around 5–10 knots. All of our turns through the auto-navigation system are based on maintaining a specific bank angle to make a constant radius of turn. Now we had a 100 knot tailwind to compensate for! This was new territory for us. I was struggling to slow the plane down and stop climbing without coming out of afterburner.

While Don and I were coping with these problems the sensors began imaging Murmansk on the right. My goal now was to maintain a stable platform for the cameras and sensors to get the best imagery possible. For the moment, trying to slow this beast down seemed impossible. We would just have to accept a higher Mach number. After passing Murmansk the plane was programmed to do a 180 degree, teardrop turn to the left and approach Murmansk from the southeast, imaging the naval fleet again off the left side. I couldn't slow the plane down, and with the tailwind knew we would fly outside our radius of turn. Fortunately, by the time I approached 80,000 feet I was able to slow the plane down to Mach 3.0, but had to use a 45 degree bank angle to compensate for the tailwind in the turn.

Heading to the northeast at 82,000 feet the aircraft held Mach 3.0 at minimum afterburner. Now that we knew how to compensate for the extremely cold temperatures we breathed a sigh of relief as we imaged Murmansk again and exited the sensitive area. The decal maneuver also left little room for error. Unlike other jets, Habus didn't have the option to change throttle settings at random or add and subtract drag devices to modify their rate of descent. The instant the throttles were brought out of afterburner to start down the bottom-out point of the decal was basically set in stone. It was necessary to manage the SR-71's engines and inlets very precisely during the decal to preclude unstarts, compressor stalls, and engine flame-outs.

About a minute before reaching the start-descent point, Don began reading from the checklist. Our descent was planned at a constant 350 KEAS down to a level-off altitude of 25,000 feet… IGV switches were set to "lockout." LN2 quantity checked to ensure there was sufficient liquid nitrogen remaining to pressurize the six main fuel tanks and stop them from crushing during the descent into the lower, denser atmosphere. Inlets checked to ensure they were still in the "auto" position and the aft bypass switch was

placed in the “close” position. Don then updated the INS altitude to the after-descent condition.

Arriving at the computed descent point, I slowly retarded both throttles to min-AB, before easing them back to the full-military position. The KEAS began to decrease and I slowly rolled the pitch wheel forward to intercept a speed of 350 KEAS and then engaged the KEAS “hold” function. The autopilot then controlled the airspeed by varying the aircraft’s pitch, while I maintained the throttles between 720 degrees Celsius on the EGT gauge and full military power.

Dependent upon the aircraft’s weight, outside air temperature, and pressure, final approach speed was about 175 knots. Touch-down speed was about 155kts and 10 degrees Alpha (positive nose-up pitch), the ground effect,

generated by the SR-71's large delta-wing, cushioning landings. (Paul F. Crickmore)

The pilot deployed the brake 'chute as the mains contacted the runway and it provided highly effective additional braking, generating an initial 2.5 negative g's pull against the crew's shoulder straps. (Paul F. Crickmore)

Passing through Mach 2.5, I slowly retarded both throttles until each gauge read 6,900rpm. Between Mach 2.5 and 1.3, I had to continually advance the throttles slightly to maintain 6,900rpm.

At flight level 600 (60,000 feet ISA), Don turned on the IFF (Identification Friend Foe) transponder and engaged mode C, for height readout, to enable

us to be identified to Air Traffic Control.

Once below Mach 1.7, I switched the forward transfer switch on, to pump fuel into tank one, to achieve a favorable forward center of gravity. Below Mach 1.3, I again checked that the bypass controls were in “auto” and “close” position. IGVs were then switched to “normal” to restore the engines to their maximum thrust capacity and at last I was able to move the throttles as necessary to adjust the descent profile.

Once below Mach 0.5, the flight control limiter was disengaged, allowing full rudder and elevon travel. Final-approach and landing speeds were based upon the weight of the aircraft, etc. But our basic final-approach speed was 175 KEAS (200mph), landing at 155 KEAS (180mph). On the straight-in approach it took very little power to hold 175 KEAS. Final approach attitude was about 10 degrees nose-up, and once near the runway overrun, I slowly retarded the power to idle and decreased the airspeed. The large delta wing and chines generated a large amount of ground effect, allowing the SR-71 to float, cushioning the landing at 155 KEAS. As soon as the main gear touched down I deployed the brake chute and jettisoned it at 55 KEAS, to ensure the heavy fitting cleared the rear fuselage before taxiing back to the “barn.”

NASA OPERATIONS

The most ambitious project to be conducted by NASA was the Linear Aerospike SR-71 Experiment, seen here mounted on the back of NASA 884, Air Force serial 61-7980. (NASA)

In 1967, the Ames Research Center of NASA negotiated with the US Air Force for access to early A-12 wind tunnel data. These tests had been

conducted at Ames sometime earlier in conditions of utmost secrecy. The Air Force decided to release the information and in return NASA provided a small team of highly skilled engineers to work on the SR-71 flight test program. In the summer of 1967, a team from the Flight Research Center was engaged on various stability and control aspects of the SR-71 flight research effort at Edwards. This work helped to speed the SR-71 into the inventory and led to the establishment of a close working relationship between the Air Force and the NASA team.

The Office of Advanced Research Technology viewed the F-12 not only as a superb technical achievement but also as a potential source of flight data applicable to future commercial supersonic transports. NASA therefore requested an instrumented SR-71 to conduct research, or have their instrumentation packages installed on other USAF Lockheed research and development aircraft. Unable to accommodate either request, the Air Force offered NASA the two remaining YF-12s in storage at Edwards. With funds available from the canceled X-15 and XB-70 programs, NASA accepted the offer and agreed to pay the operational expenses. Aerospace Defense Command (ADC) supplied maintenance and logistic support, and on June 5, 1969, a memorandum of understanding was signed between the two parties.

Three months' work was needed to ready the two YF-12s (60-6935 and 60-6936) for flight. During this time instrumentation readily available to study aerodynamic loads and structural effects was installed by Flight Research Center technicians aboard 60-6935. Strain gauges were installed within the

wing and fuselage and thermocouples mounted on the left side of the aircraft to measure high-Mach temperature readings.

On December 11, 1969, the joint NASA/US Air Force flight test program was launched when, for the first time in three years, a YF-12 climbed away from Edwards. Phase 1 of the program was controlled by the Air Force and consisted of developing procedures and establishing limitations for command and control and for working out possible bomber penetration tactics against an interceptor with the YF-12's capabilities. However, this phase of the program was terminated during the closing stages of the 63rd flight of 60-6936 when it was lost on June 24, 1971. A fuel line fatigue fracture triggered a fire that engulfed the entire aircraft while it was on base-leg, into Edwards. Fortunately both crew members ejected safely before '6936 crashed into the middle of the dry lakebed and was totally destroyed.

In contrast the NASA program was a long-running success. YF-12 60-6935 became a real workhorse for NASA. A "flight loads" research program involved installing a camera within the fuselage to photograph the structure during moderate G maneuvers. It revealed that under certain conditions the aft end of the fuselage deflected some 15cm from the centerline!

After its 22nd flight '6935 was grounded on June 16, 1970, for nine months for instrumentation changes. Once these were completed a check flight was completed on March 22, 1971, after which the folding ventral fin was removed for four flights to assess directional stability up to Mach 2.8.

During the early 1970s NASA operated two YF-12As and an SR-71A – the latter being referred to bizarrely as a YF-12C.

NASA needed more aircraft, and the Air Force supplied an SR-71A (article 2002, serial 61-7951) on July 16, 1971. For some unexplained reason, the Air Force stipulated that the aircraft had to be referred to by NASA as a YF-12C and it completed its first flight with them on May 24, 1972.

During the brief Air Force SR-71 reactivation program of 1995/96, the SR-71B pilot trainer was utilized by both NASA and Det 2. (NASA)

Studies carried out on various aspects of the aircraft's handling qualities revealed that inlet spike movement and bypass door operations were almost as effective as elevons and rudders in influencing the aircraft's flight path at high speed. Propulsion system and flight control integration was an aspect of control testing tackled in an effort to improve future mixed-compression inlet design. Airflow disturbance often culminated in an unstart, and the accompanying aerodynamic hiccups could hardly be tolerated in a supersonic passenger aircraft. This work led Lewis Research Center to develop a throat-bypass stability system, which was successfully tested on the YF-12. It used relief-type poppet valves in the inlet, which could react to internal airflow transients much faster than the bypass doors. This valve-

stabilized airflow mechanism complemented the inlet control system by providing sufficient time for the inlet shockwave geometry to reconfigure itself to maintain a “started” inlet.

Another installation tested by NASA technicians and prepared by a Honeywell engineer proved so successful that it was later fitted to operational SR-71s – the Central Airborne Performance Analyzer. This integrated automatic support system isolated faults and recorded the performance of 170 subsystems onto magnetic tape. Pre- and post-flight analysis of this onboard monitoring and diagnostic system proved highly cost effective and reduced maintenance man hours significantly.

One of the more unusual heat-transfer experiments supported by NASA was “Coldwall.” For these test flights a hollow, stainless steel cylinder was mounted under the fuselage of YF-12 ’6935, equipped with thermocouples and pressure-sensing equipment. It was then encased in a ceramic shell closed off at each end. Before flight, the cylinder was filled with liquid nitrogen to supercool it down to about minus 51 degrees Celsius. At Mach 3.0 the ceramic shell was ballistically removed, resulting in a classic heat transfer experiment as the cylinder went from very cold to very hot almost instantaneously. Using the same cylinder, this experiment was then repeated in a wind tunnel, thereby validating ground research methods for future heat transfer experiments.

Aircraft 60-6937 was retired from the program after its 88th flight with NASA on September 28, 1978. YF-12 number 60-6935 continued operating until the flight program ceased after its 145th NASA flight, on October 31, 1979. A week later, Colonels J. Sullivan and R. Uppstrom ferried the aircraft to the Air Force museum at Wright-Patterson AFB, Ohio, where, as the sole example of the YF-12, it is on permanent display.

In early 1990 NASA once again became involved in operating the SR-71 when it was decided to conduct a number of aeronautical experiments requiring the use of a supersonic test platform. Three SR-71s were placed on loan by the Department of Defense, and in order to comply with Federal Aviation Administration regulations, their serial numbers were changed: SR-71B ’956 became NASA 831, and SR-71As ’971 and ’980 became NASA 832 and 844 respectively. Like the earlier program, this too was conducted

from Edwards AFB, and the first to be readied for flight was NASA 831. The first of three training flights was conducted on July 1, 1991, after which Lt Col Rod Dyckman certified Steve Ishmael as a NASA instructor pilot. Thereafter, Ishmael checked out a second NASA pilot – Rogers Smith, who in turn flew Marta Meyer and her husband Robert on an orientation flight, as they became the two flight test engineers on the program.

The most ambitious project to be conducted during this period was the Linear Aerospike SR-71 Experiment (LASRE). Its objective was to provide in-flight data that would enable Lockheed Martin to validate the computational predictive tools it had been using to determine the aerodynamic performance of a future potential reusable launch vehicle. The first of seven flights got underway on October 31, 1997, and during this flight, which lasted 1 hour 50 minutes, aircraft 61-7980 (NASA 844), reached a maximum speed of Mach 1.2 and 33,000ft before recovering back at Edwards AFB. A second flight successfully verified the SR-71/pod configuration, and five further flights were conducted focusing on the experiment. On March 4, 1998, the first of two flights was completed, during which time gaseous helium and liquid nitrogen were cycled through the Boeing-Rocketdyne J2-S linear aerospike engine. Three more flights were successfully completed in the spring and summer of 1998, during which liquid oxygen was cycled through the engine. However, numerous cryogenic leaks were discovered, and despite the engine being "hot fired" on the ground on two occasions for a total of 3 seconds, it was deemed to be too dangerous to fire-up the engine with its liquid hydrogen fuel while aloft. An investigation into the leaks determined that these would be too difficult and expensive to rectify, and in the event, sufficient information had already been gathered to predict the hot gas effects of an aerospike engine firing during flight; therefore, the program was terminated in November 1998.

The last flight of any SR-71 took place during the Edwards AFB open house weekend of October 9/10, 1999. On Saturday NASA crew Rogers Smith and Robert Meyer flew 61-7980 (NASA 844) up to a speed of Mach 3.21 and an altitude of 80,100ft. Unfortunately it would prove to be its final flight, as the flight scheduled for Sunday, October 10, had to be canceled due to a maintenance problem.

The final NASA test team from top to bottom was Rogers Smith, Ed Schneider, Bob Meyer, and Marta Bohn-Meyer. (NASA via Mike Relja)

SURVIVING AIRCRAFT HISTORIES

Location: Blackbird Airpark, Palmdale, CA

Type: A-12

Article/Serial: 121/60-6924

Airframe Hours: 418.2

Remarks: Prototype A-12 first flew April 26, 1962, initially with J75 engines. Completed first flight equipped with two J58s January 15, 1963. On July 20, 1963, became first A-12 to reach Mach 3. Completed 322 flights before being stored at Palmdale June 6, 1968 following termination of the Oxcart program.

(Mike Schmitz)

Location: Intrepid Sea, Air & Space Museum, New York City, NY

Type: A-12

Article/Serial: 122/60-6925

Airframe Hours: 177.52

Remarks: Used for RCS pole tests June–November 1962. First flight January 15, 1963 equipped with J75 engines. Mod. to SR-71 standards April 1966–April 1967, redesignated A-12B, completed 127.9 hours of flight in this configuration before being stored at Palmdale September 16, 1967 having accumulated a total of 161 flights.

(David Allison)

Location: California Science Center, Los Angeles, CA

Type: A-12T

Article/Serial: 124/60-6927

Airframe Hours: 1,076.25

Remarks: Two-seat pilot trainer. Designated A-12T by Lockheed but listed as TA-12 in AF Form 5 – official pilots' records. First flight January 22, 1963 and equipped throughout its career with J75 engines. Completed 614 flights before being flown from Area 51 into storage at Palmdale in May 1968 by Ronald "Jack" Layton.

(Kevin Helm)

Location: US Space and Rocket Center, Huntsville, AL

Type: A-12

Article/Serial: 127/60-6930

Airframe Hours: 499.1

Remarks: First flight March 1963. One of three A-12s prepared for Operation Skylark – planned overflights of Cuba, but not implemented. Second A-12 to be deployed to Kadena AB, Okinawa on May 24, 1967 as one of three A-12s selected to implement Operation Blackshield. Flew first ops sortie June 20, 1967 and last May 6, 1968 – completing 11 in total. Positioned back to Area 51 June 9, 1968. Flown into storage at Palmdale by Dennis Sullivan June 12, 1968 having completed a total of 258 flights.

(David Allison)

Location: CIA Headquarters, Langley, VA

Type: A-12

Article/Serial: 128/60-6931

Airframe Hours: 453

Remarks: First flight June 1963. One of three A-12s prepared for Operation Skylark – planned overflights of Cuba, but not implemented. Participated in Scotch Mist – wet weather testing at McCoy AFB, FL. in 1965. Completed 232 flights before being placed in storage at Palmdale July 1, 1968. Transported by C-5 on October 27, 1991 and initially displayed at Minnesota ANG Museum, St Paul, MN before being moved to current location.

(CIA)

Location: San Diego Aerospace Museum, San Diego, CA

Type: A-12

Article/Serial: 130/60-6933

Airframe Hours: 406.2

Remarks: First flight December 1963. Used for project pilot tactical practice. Final flight August 1965, after 217 flights. Placed in storage at Palmdale June 5, 1968.

(Tony Landis)

Location: Southern Museum of Flight, Birmingham, AL

Type: A-12

Article/Serial: 131/60-6937

Airframe Hours: 345.45

Remarks: First flight February 19, 1964. Used to test Electronic Countermeasures and side-looking radar. First of three A-12s to depart for Kadena AB, Okinawa for Operation Blackshield on May 22, 1967. Also flew first operational A-12 sortie on May 31, 1967, accumulating a total of 13 before being positioned back to Area 51. Departed Kadena on June 7, 1968, but due to diverts from engine problems, finally arrived back on June 19. Positioned from Area 51 into Palmdale storage by Frank Murray on June 21, 1968 having completed 177 flights.

(David Allison)

Location: USS Alabama Battleship Memorial Park, Mobile, AL

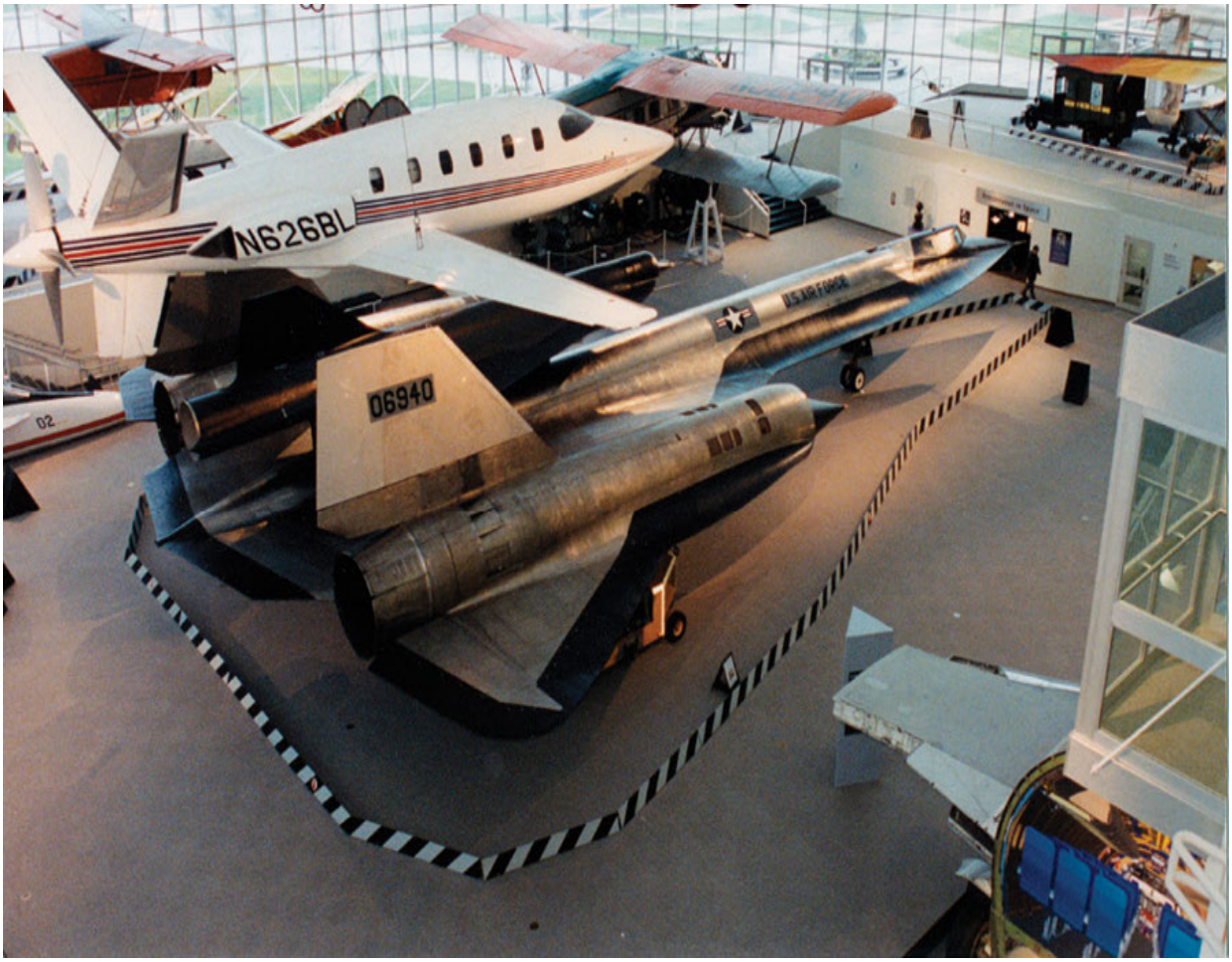
Type: A-12

Article/Serial: 132/60-6938

Airframe Hours: 369.55

Remarks: First flight March 4, 1964. One of three A-12s prepared for Operation Skylark – planned overflights of Cuba, but not implemented. Completed 197 flights before being placed in storage at Palmdale on June 1, 1968.

(David Allison)



Location: Museum of Flight, Seattle, WA

Type: M-21

Article/Serial: 134/60-6940

Airframe Hours: 123.55

Remarks: First flight December 22, 1964. Sole surviving example of two A-12s converted to M-21 configuration to air-launch D-21 drones for Project Tagboard. Used for captive trials only of the D-21 and as a high-speed chase aircraft for the other M-21 during the three M-21/D-21 separation flights. Accumulated 94 flights before being flown from Area 51 into storage at Palmdale on September 29, 1966, following the termination of Project Tagboard.

(Tony Landis)

Location: National Museum of the US Air Force, Wright-Patterson AFB, OH

Type: YF-12A

Article/Serial: 1002/60-6935

Airframe Hours: 534.7

Remarks: First flown on November 26, 1963 by Lockheed test pilot Lou Schalk. Sole surviving example of three interceptors. Following initial YF-12A test program, placed in storage at Edwards AFB. Later participated in joint USAF/NASA research program 1970–79. On November 7, 1979 aircraft was positioned from Edwards AFB to current location.

(David Allison)

Location: Prima Air Museum, Tucson, AZ

Type: SR-71A

Article/Serial: 2002/61-7951

Airframe Hours: 796.7

Remarks: First flight March 5, 1965 by Gilliland/Zwayer. Utilized during Cat. I flight test program for subsystem and sensor development testing. Participated in joint USAF/NASA research program July 16, 1971 under bogus designation and serial number YF-12C 60-6937. Flown into storage at Palmdale December 22, 1978 following program termination.

(David Allison)

Location: Air Force Flight Test Center Museum, Edwards AFB, CA

Type: SR-71A

Article/Serial: 2006/61-7955

Airframe Hours: 1,993.5

Remarks: First flight August 17, 1965. Bailed to Lockheed as systems test aircraft and utilized for max range test during Cat II flight tests. Operated exclusively by Air Force Logistics Command (AFLC) from Palmdale as test article. Deployed to RAF Mildenhall July 1983, under bogus serial number 61-7962 for operational trials of new Advanced Synthetic Aperture Radar (ASAR 1). Final flight (712 in total) completed by Lt Cols Tom Tilden and Bill Flanagan on January 24, 1985. Retired into storage January 28, 1985.

(David Allison)

Location: Kalamazoo Air Museum, Kalamazoo, MI

Type: SR-71B

Article/Serial: 2007/61-7956

Airframe Hours: 3,760

Remarks: Sole survivor of two two-seat pilot trainers, first flown November 18, 1965 by Gilliland/Belgau. First retired following termination of Senior Crown 1990. Re-activated and operated initially by NASA in 1991 before being co-operated by NASA and USAF at Edwards AFB from 1995 to 1997 during brief activation of Det 2, before reverting back to sole use by NASA until final retirement. Final flight by Ed Schneider and Bob Meyer on October 19, 1997.

(Air Zoo)

Location: Museum of Aviation, Robins AFB, GA

Type: SR-71A

Article/Serial: 2009/61-7958

Airframe Hours: 2,288.9

Remarks: First flight December 15, 1965 by Weaver/Andre. Used July 27/28, 1976 to set world absolute speed record of 2,193mph and 1,000km closed-course record of 2,288.9mph in addition to official altitude record of 85,068 feet. Last flight February 23, 1990.

(USAF)

Location: Air Force Armament Museum, Eglin AFB, FL

Type: SR-71A

Article/Serial: 2010/61-7959

Airframe Hours: 866.1

Remarks: First flight January 19, 1966 by Weaver/Andre. Modified to Big Tail configuration to enhance sensor capability. First flight in this configuration made by Darrell Greenamyer and Steve Belgau on December 3, 1975. Final flight (304 in total) completed by Lt Col Tom Pugh and Maj Bill Frazier on October 29, 1976.

(Tony Landis)

Location: Castle Air Museum Foundation, Castle AFB, CA

Type: SR-71A

Article/Serial: 2011/61-7960

Airframe Hours: 1,669.6

Remarks: First flight February 9, 1966 by Weaver/Andre. Flew 342 operational missions, more than any other SR-71. Flew one operational mission over Libya on April 16, 1986, following Operation Eldorado Canyon. Last flight February 27, 1990.

(David Allison)

Location: Cosmosphere and Space Center, Hutchison, KS

Type: SR-71A

Article/Serial: 2012/61-7961

Airframe Hours: 1,601

Remarks: First flight April 13, 1966 by Weaver/Andre. Flew operational mission on May 19, 1975, in support of SS Mayaguez incident. Last flight February 2, 1977.

(Kansas Cosmosphere)

Location: Imperial War Museum, Duxford, UK

Type: SR-71A

Article/Serial: 2013/61-7962

Airframe Hours: 2,835.9

Remarks: First flight April 29, 1966 by Weaver/Andre. Selected to participate in July 27/28 world record attempts; however, due to cloud cover on 27th and mechanical malfunction on 28th, all records were officially set and recognized by the other aircraft 61-7958. Last SR-71 flown out of Kadena AB, Okinawa by Grzebiniak/Greenwood on January 21, 1990, following termination of Senior Crown.

(Ben Dunnell)

Location: Heritage Park, Beale AFB, CA

Type: SR-71A

Article/Serial: 2014/61-7963

Airframe Hours: 1,604.4

Remarks: First flight June 9, 1966, by Weaver/Belgau. Last flight October 28, 1976.

(USAF)

Location: Strategic Air and Space Museum, Ashland, NE

Type: SR-71A

Article/Serial: 2015/61-7964

Airframe Hours: 3,373.1

Remarks: First flight May 11, 1966 by Weaver/Belgau. On November 11 and December 2, 1973, completed two of the nine operational missions flown from the eastern seaboard of the US to the Middle East and back during the Yom Kippur War. Following termination of the Senior Crown program, this SR-71 completed the last of the type's monitoring missions of the Barents Sea on its return flight from RAF Mildenhall to Beale AFB on January 18, 1990. Last flight March 20, 1990.

(Doug Soifer)

Location: Barksdale Global Power Museum, Barksdale AFB, LA

Type: SR-71A

Article/Serial: 2018/61-7967

Airframe Hours: 2,636.8

Remarks: First flight August 3, 1966 by Weaver/Andre used for maximum range tests during Cat. II flight test. Flew two non-stop operational sorties from Kadena AB, over the Persian Gulf and back on July 22 and October 26, 1987. Last SR-71 to leave Det 4, RAF Mildenhall on January 19, 1990, following termination of Senior Crown program. Stored at Palmdale February 14, 1990. Briefly reactivated as part of Det 2, 9th SRW 1995, but returned to storage October 14, 1999.

(USAF by Senior Airman Joseph A. Pagan Jr.)

Location: Virginia Aviation Museum, Richmond, VA

Type: SR-71A

Article/Serial: 2019/61-7968

Airframe Hours: 2,279

Remarks: First flight August 3, 1966 by Weaver/Andre.

Completed official endurance record of 15,000 miles in 10.5 hrs on April 26, 1971. Last flight February 12, 1990. Designated as reserve aircraft for Det 2, 9th SRW reactivation in 1998.

(David Allison)

Location: Evergreen Aviation & Space Museum, McMinnville, OR

Type: SR-71A

Article/Serial: 2022/61-7971

Airframe Hours: 3,512.4

Remarks: First flight November 17, 1966 by Weaver/Moeller. On January 25, 1974, completed one operational mission from Seymour-Johnson AFB to the Middle East and back during the Yom Kippur War. Loaned to NASA at the Dryden Flight Research Center, and renumbered NASA 832. Regularly ground tested but never flown. Positioned to Palmdale for an operational update then re-positioned back to Edwards and assigned to Det 2, 9 RW as part of the brief USAF SR-71 reactivation. Final flight in 1998.

(Stewart Bailey Evergreen Aviation Museum)

Location: Udvar-Hazy Gallery, Smithsonian National Air and Space Museum, Chantilly, VA

Type: SR-71A

Article/Serial: 2013/61-7972

Airframe Hours: 2,801.1

Remarks: First flight December 12, 1966 by Weaver/Belgau. Failure of INS during training sortie on July 2, 1967 resulted in aircraft completing first ever international sortie when it violated Mexican airspace! Established the current world speed record from New York to London on September 1, 1974 and London to Los Angeles twelve days later. First SR-71 to deploy to Det 4 RAF Mildenhall on April 20, 1976. Last flight March 6, 1990, when it established US west coast to east coast world speed record in 68 minutes.

Location: Blackbird Airpark, Palmdale, CA

Type: SR-71A

Article/Serial: 2024/61-7973

Airframe Hours: 1,729.9

Remarks: First flight February 8, 1967 by Weaver/Greenamyer. Airframe was overstressed during flight demonstration at RAF Mildenhall Air Fete May 1987. Final flight July 21, 1987.

(Mike Schmitz)

Location: March Field Museum, Riverside, CA

Type: SR-71A

Article/Serial: 2026/61-7975

Airframe Hours: 2,854

Remarks: First flight April 13, 1967 by Greenamyer/Belgau. Flew the only night mission over Hanoi of the Vietnam War on December 28, 1972, as part of Linebacker II. Between October 1979 and April 1980 assigned to Det 51/6 AFLC at Palmdale. During this time the aircraft was used to check out a new Defense Electronic (DEF) jamming system developed to protect against possible airborne threats known as DEF A2. On August 9, 1987 flew a non-stop operational mission from Kadena AB over the Persian Gulf and back. Last flight February 28, 1990.

(Stan Fry via March Field Museum)

Location: National Museum of the US Air Force, Wright-Patterson AFB, OH

Type: SR-71A

Article/Serial: 2027/61-7976

Airframe Hours: 2,985.7

Remarks: First flight May 13, 1967 by Gilliland/Belgau.

Completed first two SR-71 operational missions from Kadena AB, Okinawa, on March 21, and April 10, 1968. First confirmed SA-2 SAM firing at an SR-71 July 26, 1968. While conducting an operational mission in the vicinity of the DMZ on August 26, 1981, North Korea fired an SA-2. Last flight March 27, 1990.

(David Allison)

Location: USAF History and Traditions Museum, Lackland AFB, TX

Type: SR-71A

Article/Serial: 2030/61-7979

Airframe Hours: 3,321.7

Remarks: First flight August 10, 1967 by Greenamyer/Belgau. Completed six of the nine non-stop operational missions flown from the eastern seaboard of the US to the Middle East and back during the 1973 Yom Kippur War. Last flight March 6, 1990.

(David Allison)

Location: NASA Dryden Flight Research Center, Edwards AFB, CA

Type: SR-71A

Article/Serial: 2031/61-7980

Airframe Hours: 2,255.6

Remarks: First flight September 25, 1967 by Gilliland/Belgau. This is the last production SR-71. Flew first and third operational missions over Libya on April 15 and 17, 1986, following Operation Eldorado Canyon. Transferred to NASA in February 1990, and renumbered NASA 844. Used to conduct research programs, the most noteworthy being the LASRE. This SR-71 was the last to ever take to the skies on October 9 1999.

(Tony Landis)

Location: Hill AFB, UT

Type: SR-71C

Article/Serial: 2000/61-7981

Airframe Hours: 737.3

Remarks: This is a hybrid aircraft built as a two-seat pilot trainer to replace SR-71B 61-7957 following its loss. The forward fuselage section is an engineering test article and the aft section is from YF-12A prototype 60-6934, first flown August 8, 1963 by Jim Eastham. First flight as SR-71C March 14, 1969 by Gilliland/Belgau. Last flight April 11, 1976. Note 180.9 hours of the above figure was accrued in its previous incarnation as a YF-12A.

(David Allison)

APPENDIX 1: SPECIFICATIONS

	A-12	SR-71A
Crew	One	Two
Powerplant	Two Pratt & Whitney J58 "JJ"	Two Pratt & Whitney J58 "JY"
Max uninstalled thrust	32,500lb each	34,000lb each
Dimensions		
Span	55ft 6in	55ft 6in
Length	101ft 7in	107ft 4in
Height	18ft 5in	18ft 5in
Wing area	1,605 sq ft	1,605 sq ft
Weights		
Empty	54,600–56,300lb	56,500–60,000lb
Loaded gross	122,900–124,000lb	135,000–140,000lb
Performance		
Max speed*	Mach 3.2	Mach 3.2
Ceiling	88,500	85,500
Reconnaissance equipment		
Cameras	Perkin-Elmer Type 1	Hycon HR-308, Itek Panoramic
Elint	System 6	Ampex AR-1700
Radar	None	Loral ASARS I

APPENDIX 2: BLACKSHIELD MISSIONS LOG

Date	Mission no	Target	Pilot	Article number
05/31/67	BSX001	North Vietnam	Vojvodich	131
06/10/67	BSX003	North Vietnam	Weeks	131
06/20/67	BX6705	North Vietnam	Layton	127
06/30/67	BX6706	North Vietnam	Weeks	129
07/13/67	BX6708	North Vietnam	Collins	127
07/19/67	BX6709	North Vietnam	Sullivan	131
07/20/67	BX6710	North Vietnam	Collins	129
08/21/67	BX6716	North Vietnam	Vojvodich	131
08/31/67	BX6718	North Vietnam	Layton	127
09/16/67	BX6722	North Vietnam	Weeks	129
09/17/67	BX6723	North Vietnam	Collins	131
10/04/67	BX6725	North Vietnam	Collins	127
10/06/67	BX6727	North Vietnam	Murray	131
10/15/67	BX6728	North Vietnam	Collins	131
10/18/67	BX6729	North Vietnam	Murray	129
10/28/67	BX6732	North Vietnam	Sullivan	131
10/29/67	BX6733	North Vietnam	Murray	127
10/30/67	BX6734	North Vietnam	Sullivan	129

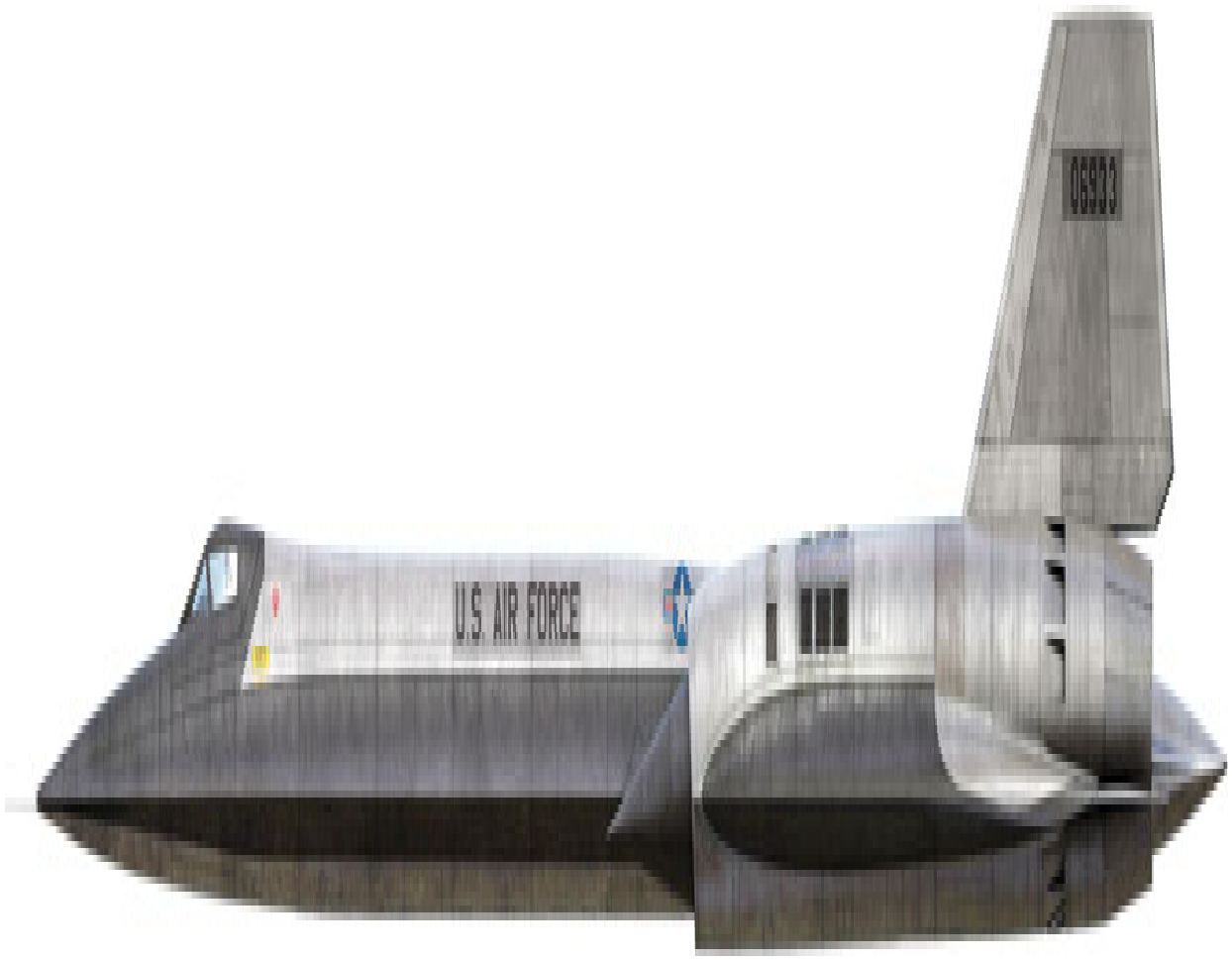
12/08/67	BX6737	Cambodia	Vojvodich	131
12/10/67	BX6738	Cambodia/Laos	Layton	131
12/15/67	BX6739	North Vietnam	Vojvodich	127
12/16/67	BX6740	North Vietnam	Layton	131
01/04/68	BX6842	North Vietnam	Layton	127
01/05/68	BX6843	North Vietnam	Weeks	131
01/26/68	BX6847	North Korea	Weeks	131
02/16/68	BX6851	North Vietnam	Collins	127
02/19/68	BX6853	North Korea	Murray	127
03/08/68	BX6856	North Vietnam	Vojvodich	127
05/06/68	BX6858	North Korea	Layton	127

SR-71A 61-7962 completed the final flight of its full and active career on February 14, 1990, having accrued a total of 2,836 flight hours. It is the only SR-71 to be found in a museum outside the United States, and it is appropriate that it is at the Imperial War Museum, Duxford, England, just a one-hour drive from the ex-home of Det 4, RAF Mildenhall.

APPENDIX 3: LOSSES

Tail No	Article No	Remarks
A-12		
60-6926	123	Crashed May 24, 1963, pilot Ken Collins survived.
60-6927	125	Crashed Jan 5, 1967, pilot Walter Ray killed.
60-6928	126	Crashed Dec 28, 1967, pilot Mel Vojvodich survived.
60-6929	129	Crashed June 5, 1968, pilot Jack Weeks killed.
60-6937	133	Crashed July 9, 1964, pilot Bill Park survived.
M-12		
60-6941	135	Converted to M-21 to carry D-21 drone. Crashed July 30,1966, pilot Bill Park survived, Launch Control Officer Ray Torick killed.
YF-12A		
60-6936	1003	Crashed July 24, 1971, both pilot Lt Col Jack Layton and Fire Control Officer Maj Bill Curtis survived.
SR-71		
61-7950	2001	Written-off on Jan 10, 1967, pilot Art Peterson survived.
61-7952	2003	Crashed Jan 25, 1966, pilot Bill Weaver survived, Lockheed Test Engineer Jim Zwayer killed.
61-7953	2004	Crashed Dec 18, 1969, both pilot Joe Rogers and RSO Gary Heidelbaugh survived.
61-7954	2005	Written-off April 11, 1969, both pilot Lt Col Bill Skliar and RSO Maj Noel Warner survived.

61-7957	2008	SR-71B, crashed Jan 11, 1968, both instructor pilot Lt Col Robert Sowers and "student" Capt Dave Fruehauf survived.
61-7965	2016	Crashed Oct 25, 1967, both pilot and RSO, Majs Roy St Martin and John Carnochan survived.
61-7966	2017	Crashed April 13, 1967, both pilot and RSO, Majs Earle Boone and "Butch" Sheffield survived.
61-7969	2020	Crashed May 10, 1970, both pilot and RSO, Majs Willie Lawson and Gil Martinez survived.
61-7970	2021	Crashed June 17, 1970, both pilot and RSO Majs Buddy Brown and Mort Jarvis survived.
61-7974	2025	Crashed April 21, 1989, both pilot and RSO Maj Dan House and Capt Blair Bozek survived.
61-7977	2028	Written-off Oct 10, 1968, both pilot and RSO Majs "Abe" Kardong and Jim Kogler survived.
61-7978	2019	Written-off July 20, 1972, both pilot and RSO Majs Dennis Bush and Jimmy Fagg survived.



Serial 60-6933 (Article 130) was the tenth A12 built (see also here)

APPENDIX 4: WORLD SPEED AND ALTITUDE RECORDS

YF-12A RECORDS

Record: Absolute Altitude, 80,257.86ft (24,390m)

Crew: Pilot Col Robert L. "Fox" Stephens, Fire Control Officer (FCO) Lt Col Daniel Andre

Aircraft: YF-12A, 60-6936

Record: Absolute Speed over a straight course, 2,070.101mph

Crew: Pilot Col Robert L. "Fox" Stephens, FCO Lt Col Daniel Andre

Aircraft: YF-12A, 60-6936

Record: Absolute Speed over a 500km closed course, 1,688.889mph

Crew: Lt Col Walter F. Daniel, FCO Maj James P. Cooney

Aircraft: YF-12A, 60-6936

Record: Absolute Speed over a 1,000km closed course, 1,643.041mph

Crew: Pilot Lt Col Walter F. Daniel, FCO Maj Noel T. Warner

Aircraft: YF-12A, 60-6936

It's probably not a coincidence that the date chosen to demonstrate some of the YF-12's awesome capabilities to the world was May 1, 1965 – five years to the day that Francis Gary Powers was shot down by a Soviet SA-2 during a Lockheed U-2 overflight. It should also be noted – impressive as these figures undoubtedly are – that they're not demonstrations of the airplane's absolute capabilities. For example, on November 20, 1965, an A-12 flown by Lockheed test pilot Bill Park attained speeds in excess of Mach 3.2 and a sustained altitude capability above 90,000ft. During the first operational deployment of a CIA A-12, from Area 51 to Kadena Air Base, on the island of Okinawa, pilot Mele Vojvodich covered the distance in aircraft Article number 131, in just 6 hours 6 minutes; had it not been for security considerations, this could easily have been recognized as a new trans-Pacific speed record. Notwithstanding, the following records verified by the Federation Aeronautique Internationale (FAI), the governing world body, were established on May 1, 1965.

SR-71 RECORDS

Record: September 1, 1974. Speed Over a Recognized Course – New York to London

Crew: Pilot Maj James V. Sullivan, RSO Maj Noel F. Widdifield

Distance: 3,490 miles. Time 1hr 54min 56.4sec

Aircraft: SR-71A, 61-7972

Record: September 13, 1974. Speed Over a Recognized Course – London to Los Angeles

Crew: Pilot Capt Harold B. Adams, RSO Capt William C. Machorek

Distance: 5,645 miles. Time 3hr 47min 35.8sec

Aircraft: SR-71A, 61-7972

Record: March 6, 1990. Speed Over a Recognized Course – Los Angeles to East Coast

Crew: Pilot Lt Col Ed Yeilding, RSO Lt Col Joseph T. Vida

Coast to Coast (2,086 miles). Time 1hr 7min 53.7sec, average speed 2,144.83mph

Los Angeles to Washington DC (1,998 miles). Time 1hr 4min 19.89sec, average speed 2,1445mph

Aircraft: SR-71A 61-7972

The US bi-centennial celebrations of 1976 provided the 9th SRW with another opportunity to break three more world absolute records. It was hoped that the attempts would be made on July 4, but due to administrative delays they were scheduled for July 27/28. Three crews and two aircraft (61-7958 and 61-7962) were made ready for the attempts. Of the sorties flown on July 27, only one record could be verified, that of Speed Over a Closed Course of 1,000km, which was set by Majors Adolphus Bledsoe and his RSO John Fuller in ’958 at 2,092mph. Cloud prevented the Nun Baker tracking cameras from recording the other flights throughout their entire course – a prerequisite insisted upon by the FAI.

Therefore, on July 28, 1976, Capt Eldon Joersz and his RSO Major G. T. Morgan got airborne in aircraft ’958 and successfully carried off the Speed Over a Straight Course Record (15/25km), verified at 2,193mph.

Next up was Capt Robert Helt and his RSO Major Larry Elliott; they strapped into ’962 to re-run their altitude attempt of the previous day; however, due to a maintenance issue they ground aborted and switched into ’958 and it was in this aircraft that they established an Altitude in Horizontal Flight record of 85,068ft.

Lt Cols Ed Yeilding and his RSO J. T. Vida flew ’972 on its record-breaking coast-to-coast flight on March 6, 1990, during which they averaged a speed of 2,113mph. (Lockheed Martin)

Finally, despite all that some SAC officials could do to prevent more headline attention after the program was prematurely closed down, Senior Crown went down fighting and established the following.

Acknowledgments: The information for this book is an accumulation of interviews and declassified documentation that spans over 30 years. During that time there have been dozens of crew members, maintenance specialists, and others that have all made important contributions – several have become lifelong friends; some, unfortunately, are no longer with us. To them all, both past and present, I offer my most sincere and grateful thanks. I would, however, like to single out the following who have been especially helpful: SR-71 pilots Cols Rich Graham, Don Walbrecht, and CIA A-12 pilot, Lt Col Frank Murray. I'd also like to thank General Pat Halloran, Lt Cols B. C. Thomas, Blair Bozek, and Tony Bevacqua, Tony Landis, Mike Schmitz, Bob Archer, Dave Allison, Stewart Bailey, Ben Dunnell, Toni Hiley, Kim Robinson, Amy Russell, Lindsay Peacock, Yefim Gordon, Kev Gothard, Stewart Bailey, Flt Lt Adam Crickmore, Paul Suhler, Patrick Cook, Laurie Gatt, and my editor Russell Butcher. Last but by no means least I want to thank my amazing wife Ali for all her love, support, and forbearance.

Front cover: On August 26 1981, SR-71 61-7976 was flying in the DMZ between North and South Korea, when the North fired an SA-2 at them – luckily the missile missed them (see here).

Title page: Eight A-12s, including the AT-12 two-seat pilot trainer together with two YF-12As, can be seen at the end of this impressive line-up taken at Area 51 during the Oxcart flight test program. (Lockheed Martin)

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